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The Philippine Agriculturist and Forester

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Vol. IV | January, February 1916 | No. 9-10

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LOS BAÑOS, PHILIPPINES

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Vol. IV | January, February 1916 | Nos. 9-10

EDITORIAL

A Memorable Day

Expositions are usually held in large cities, where there is a fair chance to secure a respectable crowd; but in an out-of-the-way place, surrounded by uninhabited forest and sparsely-inhabited districts, the prospects of sucessfully holding such an event are of a rather doubtful nature. Not so, however, with the College of Agriculture, although it is supposed to be isolated—for the exposition held January twenty-ninth surpassed all expectations. Visitors representing people in all walks of life came in great numbers from the city and the provinces near-by, and all enjoyed together what the College had to show the public, as representative samples of the more important results of its work.

The principal center of attraction was in the newly-constructed building, intended for a tobacco house, but fitted up for the occasion to contain the exhibition of the Department of Agronomy. Here the chief points of interest were the different weeds and cultivated plants used as source of fiber, and the fibers obtained therefrom; the coffee exhibit representing methods of cultivation and control of diseases, and varieties more or less immune to rust; the coconut booth where the secrets of coconut culture could be learned; specimens of different varieties of rice, sugar cane, root crops, and garden vegetables, all tastefully and systematically arranged; and demonstrations of many of the local fungus diseases of crops. An effort was likewise made in the same building to advertise "THE PHILIPPINE AGRICULTURIST AND FORESTER," resulting in the addition of an appreciable number of new subscribers to the Business Manager's list.

The Laboratory of the Department of Entomology also contained an exhibit, consisting of injurious insects and their work; beneficial and harmful birds and other animals; and zoological materials for the study of comparative

anatomy. A noteworthy feature which attracted much attention was the display of mulberry and eri silk-worms and their products. Papers on the possibility of silk culture in the Philippine Islands were prepared in both English and Tagalog and posted near the display cases, where the visitors could easily read them. The lack of room necessitated the transfer of many of the exhibition materials of this Department to the glass cabinets of the Auditorium.

The Department of Botany prepared interesting demonstrations to show the behavior of plants under varying conditions; and the Department of Chemistry had experiments in operation, showing the interest and practicability of its work.

The College farm, the nurseries and trial plots, the gardens, and the pig and the poultry pens, were inspected by the visitors, with the help of student guides A large amount of cuttings, seeds and seedlings was distributed free.

The occasion can hardly be done justice to without at least a passing mention of the encouraging utterances of the prominent visitors of the Exposition, which had for their general tenor an appreciation of the work of the College of Agriculture, and a plea for a more adequate general support from the public. It was late before the crowd dispersed, with expressions of regret that they were not able to stay longer. The day following brought us, likewise, a goodly number of visitors; and on the following Monday we found ourselves enjoying the satisfaction of favorable comment by the press, notably by "El Ideal," which characterized the occasion as "a great day for the Filipino people."

L. B. U.

ANNOUNCEMENT

The Dean of the College of Agriculture has issued the following announcement:

The vacation session of the College of Agriculture will open Monday, April 10th, 1916. Monday forenoon will be devoted to matriculation and work will begin in earnest Monday afternoon. At this session, there will be an opportunity for students already in the college to make up work in several departments.

Botany I will be given to new students and to old students who have failed to pass this course. Not more than fifty (50) students can take this course with advantage during the vacation, and as the number of candidates seems likely this year to be more than fifty, they will be admitted in the order of their matriculation in this college.

It is strongly recommended that students who already have credit for one year or more of high school work, and who intend to transfer this year to the College of Agriculture, take Botany I during the summer instead of waiting to begin in June. Failure to finish Botany I during vacation is likely to result in serious difficulty in making a program of studies during the following years.

It is also in the interest of the students who expect to support themselves at the college that they take Botany I during vacation, before beginning the other first-year subjects. If they have finished Botany I, they may matriculate in but three subjects during the regular college year and thus save the time which they need in order to earn their living.

Students coming directly from the intermediate schools, and not dependent upon their own efforts for their current expenses, are advised not to attend the summer session.

If the number of applicants for admission is greater than can be accommodated in Botany, students who have had at least three years of high school work will be permitted to take the latter half of Mathematics III, Trigonometry and Surveying, during the vacation.

Growth of Legumes as Influenced by Lime

By Amando Laparan y Layosa

Thesis presented for graduation from the College of Agriculture, No. 27

The use of lime for the improvement of agricultural soils is very ancient. The Chinese were probably the first to use lime in this way, but mention of the same practice is found in Latin works written before the beginning of the Christian era. With the development of modern agricultural practice and the general use of fertilizers, countless experiments with lime have been performed, and its use has become general in a number of lands.

Statements attributed to Deherain, Muentz and Guard are to the effect that more than one-fifth of the area of France responds conspicuously to treatment by lime, and that in some regions there has been a veritable agricultural transformation as a result of its general application. Similar statements ascribed to Wicke and Schultz are to the effect that the application of lime in the form of marl has multiplied the yield in parts of Germany by four and has made hitherto useless soils very valuable.

Lime has been used in the United States as a fertilizer for fully a century. Publications of the United States Department of Agriculture and of many of the state experiment stations deal with this subject. Among the station publications, should especially be mentioned *Michigan Agr. Exp. Stat., Circular* No. 10, June, 1911, by Patten and Jeffery; *Iowa Agr. Exp. Stat., Agronomy Bulletin* No. 2, August, 1911, by P. E. Brown; and *Massachusetts Agr. Exp. Stat., Circular* No. 20, Febbruary, 1909. All of these agree that lime acts on the soil in three distinct ways—chemically, physically, and biologically.

The most important chemical action of lime upon a soil is to "correct acidity." Soils that have been cultivated for a great many years may become acid due to the accumulation of organic materials.

Some of the less soluble potash compounds of the soil are rendered available.

Phosphoric fertilizers, especially of less soluble materials, are often rendered more effective.

Injurious compounds of iron, and perhaps other injurious compounds, are rendered harmless.

Organic matter decomposes more rapidly and the plant food it contains becomes more promptly available. This action is most important in its relation to nitrogen. It is especially valuable in heavy soils in which organic matter naturally decays slowly.

Physical action of lime:—Heavy clay soils that puddle and bake after a rain are benefitted by the addition of lime. It acts beneficially upon a soil in this condition in that fine particles are bound together in "crumbs," thus making the soil more friable and easy of cultivation. It also makes the soil more open and porous, thus facilitating the movements of air and water. The action of lime on sandy soils is quite the reverse of that on clay soils since it binds together the loose particles of the sand and makes the soil more retentive of moisture.

Biological action:—It is already known that the decomposition of organic matter added to the soil in the form of barnyard manure and green manure, is brought about by organisms that live in the soil. Certain soil bacteria, that live in connection with the roots of legumes such as clovers, beans, etc., are able to take nitrogen from the air and change it to an available form, and the bacteria will accomplish their work only in the presence of lime."

While all writers on the subject recognize the fact that lime is essential as a chemical constituent of the food of plants, there has been a rather general disposition among agricultural writers to pay inadequate attention to this phase of the utility of lime. It is, of course, true that, the world over, lime is more generally present in quantities sufficient for the demands of vegetation for its food than are nitrogen, potash and phosphorus. But it is also true that soils deficient in lime as an element of plant food are by no means rare. It is also true that plants vary in their demand for lime much more widely than they do in their demand for the other three elements just mentioned, and that on soils with sufficient lime for some plants such as maize, the amount of this element may still be insufficient for the thrifty development of other crops, for instance, the legumes. Beside a certain amount of lime which must be present for the manufacture of a given amount of dry material, and which is more or less independent of the presence of other substances, plants also require a balance, even if a quite indefinite one, between the amount of lime and the amount of other substances present. This use of lime has received the fullest discussion by Loew in publications of the Japanese College of Agriculture and the United States Department of Agriculture.

With specific regard to the application of lime to legumes, experiments are reported in *Wisconsin Agr. Exp. Stat. Bulletin,* No. 230. These experiments were mostly performed in sandy soils in the central and northern parts of the state. The application of lime to alfalfa land resulted in increased yields of 43.3% and 55.2%, and in an extreme case, in the production of a crop while the unlimed control was a complete failure. Mammoth clover showed an increased yield of 42% as a result of the use of lime. With soy beans, yields were increased by two-thirds and by three-fourths and in one case were more than doubled.

In the Philippines (*Boletin Official Agricola de Filipinas*, Vol. I, page 175, June 1894), fertilizer experiments were performed with maize in Cebu by Vicente W. Pastor, with the following results:

	Hectoliters per Ha.
Soil and subsoil mixed with manure	10.50
With lime	6.36
With human excreta	6.25
Manure alone of cattle	5.85
Marl	5.00
Guano	3.50
Native culture	1.08

With the exception of the first mixture, the use of lime gave the best return.

Stangl has reported that the application of lime to rice land resulted in an increased production of 26% in Bulacan and 22% in Bataan, and that the application of lime resulted in the production of grain of larger size.

As to the utility of different forms of lime, statements of Patten and Jeffery, already cited, are of interest because they deal with the form in which it was applied in our experiments. According to these writers, 1000 pounds of burned lime is equivalent to:

1,351 pounds hydrated lime.
1,786 pounds ground limestone or marl.
1,351-1,786 pounds air slacked lime.
About 3,000 pounds hardwood ashes.

The same writers also recommend the use of a lime spreader to prevent the irritation of the hands as a result of its caustic properties, and suggest the distribution of lime in piles two rods apart, from which it can be scattered with a shovel. After application in this manner, the field should be harrowed to insure even distribution. A manure spreader can also be used to scatter lime.

Experimental Work

In my experiments, lime, was used in the form of burned lime known also as stone lime, lump lime, quick-lime, and caustic lime. It is produced from the raw lime-rock by burning. Good lime-stone is expected to produce 56% of burned lime.

Land previously in cogon, subsequently planted to maize, soy beans, and maize in turn, was cleaned, plowed and harrowed several times until pulverized and loose. This was done in June, when cultivation was easy and effective as a result of previous rain. The soil had never been manured or fertilized. In character, it is a rather heavy clay loam. A plot, 27.5 meters by 22.32 meters, was divided into five smaller plots by paths a meter in width. Each smaller plot had an area of 128.75 square meters and was marked off into six rows 75 centimeters apart. The rows were furrowed with a hand plow to a depth of about 15 cm. In each of these smaller plots, the first two rows were left unlimed, as a check. The next two were limed at the rate of 1,500 pounds (672 kgs.) per hectare, and the last two rows, at the rate of 2,500 pounds (1,136 kgs.) per hectare. The lime was evenly broadcasted in the furrows and covered thinly with fine soil before the seed was planted.

The plants used were cowpeas in the first plot, Psophocarpus in the second, soy beans in the third, and mongos and kulthi in the last.

Seed of the first four kinds was planted June 26, 1913, and the kulthi was planted two days later. The weather at the time was very wet, which prevented good germination of cowpeas and kulthi and necessitated replanting. Germination of mongo, soy and cowpeas began in three days and was completed in five days. Germination of kulthi and Psophocarpus began after seven days.

Growth measurements began July 12, as soon as thirty apparently uniform plants of each kind could be obtained. These measurements of ten plants of each kind under each set of conditions were repeated weekly through the time of active growth of most of the plants. The measurements were all in total length, measuring from a fixed point on the ground, and the difference between two successive measurements represents the weekly growth.[1] Because of excessive rain from the beginning of the experiment, the cowpeas and mongos failed to thrive in any of the rows.

The only cultivation given these plants was by hand, and this was only sufficient to keep the soil reasonably loose around the plants and to keep the plots free from weeds. As soon as growth had practically stopped, the plants were pulled up, with as much of their roots as could conveniently be pulled up with them, and weighed; the results are shown in the following table.

Total Weight of Vegetable Matter Produced in Kilograms.

		Lime	*Increase.*	*Lime*	*In-*
	No Lime.	*1500 lbs.*		*2500 lbs.*	*crease.*
Kinds of plants.	*Wt.*	*Wt.*	*%*	*Wt.*	*%*
Soy beans....	15.4	22.6	37.5	19.8	28.5
Psophocarpus.	8.64	20.6	138.5	16.2	87.4
Kulthi.....	36.6	44.7	22.1	51.1	39.6

As this table shows, the application of lime was followed by an increased yield in each case. Some advantages from its use was also shown by the growth of the cowpeas and mongos. In the cases of soy beans and Psophocarpus, the best result was obtained by the lesser application of lime, while kulthi made the heaviest yield with the heavier application. The increased yield was most conspicuous in the case of Psophocarpus.

1 Mr. Laparan submits with his thesis a complete set of tables showing total height and growth as indicated in the text. These

measurements fully substantiate his conclusions; but as the conclusions follow likewise and with sufficient clearness from his statements of yield, the tables of growth records are not published here.—E. B. C.

To test the effect of lime under different climatic conditions, the experiment was repeated beginning in November, and using plants of the same kinds. The experiment was on soil of the same kind, which likewise had never been manured or fertilized before; and the arrangement of the experiment was the same as already described. Because of previous dry weather, it was difficult to make the soil fine and loose. As before, the only cultivation given was by hand. Growth measurements in this series began November 29, and were continued until there was a good production of fruit; this was January 17 in the case of mongo and cowpea, and January 24 in the case of soy, and February 7 in the case of Psophocarpus. The production from each plot is shown by the following table:

Total Weight of Vegetable Matter Produced in Kilograms

Kinds of plants.	*No Lime. Kg.*	*Lime 1500 lbs. Kg.*	*Gain %*	*Lime 2500 lbs. Kg.*	*Gain %*
Cowpeas.....	3.740	2.780	–25.6	2.70	—27.8
Mongos.....	1.295	1.120	–13.5	1.080	–16.6
Psophocarpus.	8.260	10.710	29.6	10.310	24.8
Soy-Beans....	4.77	6.16	29.1	5.280	10.7

As this table shows, both mongo and cowpea produced a greater amount of vegetable matter on the unlimed plots than in the limed plots, showing that in the time of drought these plants are injured by lime in the quantity applied. Psophocarpus and soy showed an increased yield as the result of liming, but in both cases the increase was greatest with the lighter application. The growth records shows that the increase, due to the application of lime to Psophocarpus and soy, was very largely confined to the latter part of the period of vegetation.

The growth records also show that kulthi grew somewhat better on the limed plots than on those untreated. Because of drought, the kulthi failed to mature and is therefore not represented in the last table.

Conclusions

1. On the College soils and under the conditions of these experiments, the use of lime for the production of Psophocarpus, soy-beans and kulthi is beneficial, while to cowpeas and mongos it is not so.

2. In the case of Psophocarpus and soy-beans, the application of 1,500 pounds per hectare gave a better result than the application of 2,500 pounds per hectare.

3. In the case of kulthi the 2,500 pounds per hectare gave a greater yield than the 1,500 pounds per hectare.

4. The effect of lime on the production of legumes varies with the season, in that it gave a better result during rainy weather than in dry.

Acknowledgment

These experiments were performed under the supervision of Professor Charles F. Baker, whose valuable advice is gratefully acknowledged.

A Study of Cowpea Culture with Special Reference to Selection in the "New Era" Variety

By Agripino Constantino y San Juan

Thesis presented for graduation from the College of Agriculture, No. 42

Introduction

The cowpea, botanically known as *Vigna sinensis* Endl., is a plant with which the Filipino farmer has had little opportunity to become acquainted. He produces, for family use only, the long-pod variety, known as "sitao" or "paa-yap," in small patches of ground outside the door or in the backyard. But he knows little of the value of cowpea as a soil renovator, as a green manure crop, as a forage crop, and as a human food; common ways in which the plant is used in countries where modern agriculture is practiced. As this country develops, and its agriculture improves, there is every reason to believe that this important leguminous plant will grow in popular appreciation, so any effort toward bringing it to its maximum productivity in the most economical way should be of practical benefit.

In the southern United States, cowpeas are grown extensively, not only because of their high nutritive value as food for human beings and animals, but also for the fertility they add to the soil when they are used as cover crops or green manure in rotation with other crops. Cowpeas, as most other legumes, are able to use the free nitrogen of the air by the aid of the bacteria which live upon their roots. The plowing under of a crop of cowpeas will increase the supply of humus and nitrogen in the soil and even when the crop is harvested for hay or seed some increase in soil nitrogen will result from the decay of the roots left in the soil. Not only is nitrogen added to the soil by growing cowpeas, but experiments and observant producers of the crop agree that the plants greatly improved the tilth, or friability of the soil.[1]

Although so important a crop, very little has been done as yet, towards its improvement by means of systematic selection and breeding, although experiments along this line with other crops, as corn, tobacco, cotton, and wheat, have given valuable results. If experiments in seed selection and breeding are made with cowpeas, the following characteristics should be taken as the basis of the work:

1. Earliness of maturity.
2. Resistance to disease.
3. Productivity.
4. Uniformity of product.
5. Evenness of maturity.

It is important also to take into consideration the habit of growth, the more erect and bushy plants being most easily handled by machinery.

Origin and History of Cowpeas

There has been much discussion as to where the cowpea originated.[2] According to J. G. Smith,[3] it was first introduced into the United States through the efforts of a South Carolina planter who received a quantity of seeds from a foreign source, which, according to certain authorities, was either an English acclimatization society or the captain of a trading vessel from India or China. From this obscure beginning, cowpeas spread throughout the South, and now their cultivation reaches as far north as Connecticut, New York, and South Dakota, and westward to California. Wight[5] makes the following statement: "Although the cowpea is the chief leguminous crop of the Southern United States, the most diverse and often erroneous ideas prevail in regard to its geographic origin and the time and means of its introduction into Amer-

ican Agriculture." It has been maintained by some, for example, that it is a native of tropical America; by others, that it was brought from Africa by a negro slave; and still others claim that it was introduced by the United States Department of Agriculture. Wight asserts that it was introduced first into the West Indies during the latter half of the 17th century, and probably reached the mainland during the first half of the 18th century. Recent authorities are convinced that its original habitat was India, China, or Tropical Africa.

The term "cowpea" is the common name of *Vigna sinensis* Endl. The supervising committe of the N. C. State Horticultural Society makes the following statement (The Cowpea, p. 5) "The cowpea's botanical name is *Vigna sinensis*, and although commonly called a "pea," it is, correctly speaking, neither a pea nor a bean, and differs widely from both. To be sure, they all belong to the same family (Leguminosae) but so do clovers, alfalfa and vetches." One of its Hindo or East Indian names is "Cowlee," and Professor Brewer thinks that the enthusiastic philologist might see a corruption of that term in cowpea, but he adds that there is no evidence of the connection of the two names other than sound. Watt says: "The nomenclature of the cultivated varieties of cowpeas is almost hopelessly confused. Formerly, the name cowpea was restricted to the Buff-colored or Claypea (varieties of *Vigna sinensis*), but now it is commonly used generically." In literature other than American, the cowpea is often known as China bean and black-eye bean.

There are about fifty known varieties of cowpeas but only a few of these are extensively cultivated. The varieties differ in such characters as size, time of maturing, productivity, resistance to disease, and especially in the color of the seeds, the latter being either entirely white, red, buff, black or blue, or variously blotched or speckled. New varieties are constantly appearing as a result of selection or of hybridization. A result of this is that one variety may be cultivated in a dozen different places under as many names, or a dozen different strains may bear the same name.

Soil for Cowpeas

Grown on nearly every kind of soil, the cowpea makes a profitable crop, if supplied with the necessary amount of moisture and given good culture. However, some soils are better adapted to the plant than others. Sandy loams that are porous, so that they allow aeration, produce a better crop than clay loams. If planted on the clay soils the deep rooting habit of the cowpea mellows the soil, so that the crop of the second year is better than that of the first. Soil that will grow corn successfully will, as a general thing, be found adapted to the production of cowpeas. Very fertile soils are not desirable; on such soil the plant produces an excessive growth of stem and foliage, which, on account of the succulence, makes it very difficult to cure into hay. Grown on this kind of soil the plant also tends to produce fewer seeds. It is evident that a soil of medium fertility is to be preferred for the production of the cowpea. Wet soil is to be avoided as the seeds rot, and only with the most careful culture can the cowpea be grown successfully by the "dry farming" method.

The same preparation of soil should be made for cowpeas as for corn. The ground should be plowed early and later cultivated with the disk harrow to destroy weeds, clean away stubble of previous crops, and produce a soil mulch to absorb and retain the moisture. If the soil is loose, it will then be ready for planting.

The common Filipino method of preparing the soil for this crop is to plow the ground and then allow the weeds to dry, or if immediate planting be desired, the land is gone over with a bamboo harrow after the plowing, to break and pulverize the clods, check the early growth of weeds, and make the handling of the soil at the time of planting easy. Where soil has been under cultivation for a long time one plowing and harrowing is usually all that is necessary.

Culture

The methods of planting cowpea vary in different localities; planting methods vary also according to the purpose for which the crop is grown. For the production of seed the best practice is to plant in rows. This allows easy and convenient cultivation and weeding, and gives the plant more space for normal development and the production of a heavy yield of seed. Another advantage of this method is that it requires less seed to the hectare. In dry weather it is advisable to practice a method of listing, that is, planting the seed in furrows five to ten centimeters deep. In early cultivation, the weeds in the furrows are readily destroyed by covering them as the furrow is filled. Care should be taken not to list the seeds too deeply for they then start slowly and usually do not develop well.

When the cowpea is planted for hay or for green manuring, the best way is to broadcast the seed. When this method is used the plants do not vine so much but tend to grow upright; they are easy to harvest with a mower, and make less woody hay. [3] However, the large amount of seed required, and the impossibility of cultivation, are practical objections to this method of planting.

If cowpeas are planted 50 cm. apart in rows 80 cm. apart, they may be cultivated in much the same way as corn. Planting in close drills, like broadcasting, prevents any cultivation and so is not recommended. Planting in furrows, with a distance of 40 cm. to 50 cm. between plants, and 80 cm. to one meter between rows, is the method generally followed in this College.

Three passings with a cultivator are usually all that are required, the last being done just before the plants bloom. Nothing is gained for seed production by cultivating cowpeas after the blossoming period, as such late cultivation causes dwarfing and delays maturity. Cultivation should be avoided when the dew is on, as the soil thrown against the damp cowpea vine will adhere to the plant and may cause the development of harmful fungus diseases.

Harvesting and Threshing

One of the drawbacks to any extensive cultivation of cowpeas for seed is the expense of harvesting the pods. As machinery for this purpose has not yet been perfected, the pods have to be picked by hand as soon as they ripen. In New South Wales, the pods are picked by men and boys who go through the field with baskets or bags attached to their waists. They are paid at the rate of 5 shillings (a) per hundredweight (b) for seeds in the pods; when the crop is good they can earn from 7 to 10 shillings per day. Three hundredweights of these seeds in pods give, when threshed, one bag of seed weighing 109 kilos. In most cowpea regions in the United States, hand-picking is the common method used. The cost ranges from ₱0.80 to ₱1.50 per hundred pounds of pods, or the picker is given from one-third to one-half of the total quantity gathered.

Where the cowpea is harvested for hay, the plants should be cut when most

(a) 1 shilling = 48 centavos.
(b) 1 hundredweight = 91 kilos.

of the pods are developed, and the first pods and some of the leaves are beginning to turn yellow. At this stage, the plant has attained its full growth and no leaves are lost. If the plants be cut too early, the vines willl be watery and difficult to cure, while if cutting is delayed, there will be an unnecessary loss of leaves in handling and the stems will be tough and hard.

A common method of threshing cowpeas in small quantities is to put the pods in bags and then flail them. The seeds are threshed out with comparatively little work when the pods are dry and brittle so that the shells separate easily. The bruising of the peas is one objection. Another objection to the use of the flail is that the hulls break into fine pieces and it is difficult to winnow the seeds unless there is a machine suitable for the purpose.

In the work of selection, where the pods from individual plants are handled separately, it is necessary to open the pods singly, by hand, to avoid mixture of the seeds and injury to them by cracking.

Selection of Seed from Parent Stock

The work of selection of cowpeas as treated in this paper was begun when most of the pods were matured. The entire field was gone over and each plant was carefully examined for the characters taken as the basis of experimentation. As the principal end in view was to secure a crop that would give a heavy yield of seed and produce a large amount of green matter, careful attention was given to individuals having these characteristics. Where these characteristics did not appear to be due to the amount of plant food available in the soil, all plants exhibiting them were labeled with white tags. The selected plants were numbered consecutively and seeds picked from them were labeled correspondingly. As they ripen unevenly, the harvest requires some time.

The seeds used in the present study were furnished by the Agronomy Department of this College. They bear the same variety name under different College numbers. One of these has already passed its first generation, and the other the second generation. Their college numbers, variety name, and origin are shown as follows:

College No.	*Variety Name*	*Origin*
606-F1..	"New Era".	U. S. Dept. of Agri., Sept. 23, 1912.
737-F2..	"New Era".	Bureau of Agri., Manila, P. I., Nov. 25, 1912.

Of the many varieties tested in this College, only the "New Era" has proved a success. Among those that did not succeed were Groit, Catjang, *Vigna cylindrica*, Brabham, Taylor, Early Buff, and Moneta. The above were planted August 27 to 29, 1914, in the trial beds.

H. T. Nielsen[8] describes the "New Era" cowpea as follows: "The New Era is the smallest seeded of the cowpeas that have found a wide use. The seed is bluish in color owing to the innumerable minute blue specks in a gray back ground. The New Era is the most nearly erect of any of the varieties, rarely having any prostrate branches. It usually produces a heavy crop of seed and matures in from 70 to 90 days. It is one of the earliest of the cowpeas and is the most easily handled by machinery. The small seed is not usually considered an undesirable character as a smaller quantity is required for seeding than is the case with other varieties."

Experiments

The work in selection for this study was begun on May 20, 1914. At that time pedigreed seeds could not be obtained. A tract of ground, 28 by 28

meters, was planted with the "New Era," number 732-F2. The soil is a loose clay loam. The seeds germinated in three days, which, under favorable conditions, is the normal length of time required. The field was given the usual care and cultivation. At first the plants showed good growth, and up to the second week after planting no sign of disease was noticed; after this it was observed that from different causes the plants began to die. A maggot (*Agromyza* sp.) which enters the stem near or under the surface of the ground caused the death of some of the peas. Others were killed by plant lice which attacked the leaves and petioles, causing them to turn white and wilt. Some plants that were not attacked by insects did not withstand the rainy weather which prevailed at this time; their growth was retarded, or they died.

On July 1st another field was prepared and on the next day was planted with seeds of the same variety used in the first planting. The seed showed a good percentage of germination. After germinating, the plants suffered from several rainy days with occasional hard storms. As in the case of the previous planting, the cowpeas did not give a good stand and did not develop well. This failure was probably due to the unsuitable weather to which the plants were subjected.

On August 1st, after rain, another plot of ground was prepared and was immediately planted. As in the previous cultures, the seed gave a good percentage of germination. On August 14th, two weeks later, another patch of ground, adjacent to the preceding field, was planted. In both fields, the distance of planting was 46 by 80 centimeters with 2 or 3 seeds in a hill. The plants in the first plot, planted August 1st , showed their flowers on September 17th. The early flowering ones were each labeled by driving a short stick at the base of the plant. The second planting flowered from September 26th to 30th. The first ripe pods in the first planting were found September 28th, and in the second, October 21st, 1914.

Selection of Seed

In the first selection, very many individual plants were taken, and after examination, those showing the poorest pods and seeds were discarded, only the superior individuals being retained. These furnished the material for the first selection.

Remarks: When the selection of these plants was being made, it was observed that plants near each other and having equal spaces and exposure to heat and light showed certain peculiarities. Some flowered early and matured quickly; others were late and viny, and still others were short and had few fruits. Of two or three plants standing in one hill, one was found diseased while the others showed no sign of disease.

Very late individuals, although yielding a fair amount of forage foods, were not included in the selection. Occasionally, there were found plants bearing many pods, but the seeds were small and loose in the pod, so that the weight of the dry seeds, per hundred, fell far below the average. These also were discarded.

In selecting for the production of a large amount of green matter, for forage, or for hay, the choice must be confined to the rank-growing individuals. While this characteristic may, with a fair degree of certainty, be determined by the general appearance of the plant, the only sure method is to weigh the vegetable matter.

In order to obtain the result in the least time possible, having a limited time to carry out this work, the author

planted the seed from the above selected plants at a different planting season than that of the first planting. In each case, however, seed reservations were made for planting again in the same season.

Out of a number of thousand plants studied, 13 were selected as exceptional in the production of forage, while 16 were selected as exceptional grain producers. In certain characters these two series were similar. All attained the height of about 49 centimeters. The size of pods was about 16 cm. by 0.76 cm. The number of seeds in the pod averaged 14 in both cases. The size of the seed in both lots averaged about 7½ mm. by 5½ mm. The weight of 100 dry seeds was slightly greater in the plants selected for forage. However, here all similarity between the two lots ceases.

The characteristic features of the series selected for forage are as follows:

The weight of above ground vegetable matter varied from 850 to 1206 grams, averaging 967 grams. The number of pods on a plant varied from 42 to 97, averaging 64. The weight of pods in grams varied from 73 to 242, averaging 136. The total weight of dry seeds varied from 43 to 128 grams, averaging 76 grams.

The characteristic features of the series selected for grain are as follows:

The weight of vegetable matter above ground varied from 463 to 1,206 grams, averaging 715 grams. The number of pods per plant varied from 69 to 97, averaging 76. The weight of pods in grams varied from 94 to 242, averaging 152. The total weight of dry seeds varied from 32 to 140 grams, averaging 93 grams.

The detailed data have been arranged in tabular form (not given here) for use in connection with the continuation of the test cultures.

Influence of Selection

That certain selected plants will transmit their character to the progeny, can only be ascertained by planting. In plant breeding, it is desirable that the seeds of the selected plants be planted in a field by themselves.[11] This insures that only progeny of carefully selected plants will be planted near together, and thus no ordinary stock will enter in as a contamination. Accordingly, our selected seeds were planted separately, 75 centimeters apart, in beds one two-hundredth of a hectare in size. Some of these seeds were planted in test-rows. Precautions were taken that no mixture of seed from different plants might occur.

It would not be fair to compare the yield and other characters of the selected plants with those of the original stock, because the selected seed was planted at a different time, and the condition of the weather might have influenced their development. In order to have a fair comparison, a check was also planted from the common stock culture.

Note: As stated above, all the selected plants were planted in beds and test-rows. The test-rows gave no results worth recording, but the beds yielded valuable data.

From each one of the beds representing the progeny of a single selected parent, a considerable number of average individual plants were taken out for the recording of the characters in detail. The averages of the statistical characters of these plants are given in the table which follows:

TABLE I

AVERAGES OF GENERATION II

				Pods				Seeds			
Bed Number		Height in cm.	Wt. in Gr. of Veg. matter	No. of pods	Wt. in Gr.	Size in cm. L. X. W.	Ave. No. of seeds per pod.	Size in mm.	Wt. in Gr. of total dry Seeds.	Wt. of 100 Seeds.	Length of longest Stem cm.
223	(a).....	35.6	301	30	53.34	15.93×.75	15	6.67×5.7	39.14	10.17	47.6
225	(b).....	37.75	301.6	27	50.85	17.9 ×.716	16	6.58×5 35	37.246	10.9	43.12
226	(c).....	38.8	237.5	26	53.33	16.03×.78	15	6.8 ×5.6	39.2	10.91	62.0
227	(d).....	40.14	313.4	23	60.98	16.36×.75	13	7.14×5.54	42.5	12.2	76.
237	(e).....	38.0	296	28	51.93	15.32×.76	15	6.37×5.38	37.1	10.16	42.
Average.....		38.06	289.9	27	54.08	16.23×.76	15	6.71×5.52	39.03	10.70	54.15

NOTE: (a) Average of progeny of Plant No. 5, Selection I.
(b) Average of progeny of Plant No. 11, Selection I.
(c) Average of progeny of Plant No. 14, Selection I.
(d) Average of progeny of Plant No. 16, Selection I.
(e) Average of progeny of Plant No. 4, Selection I and No. 3, Table II, Selection I.

Seeds were planted in a check bed in the same kind of soil at the time the selected plants were planted. The distance of planting and the cultural treatment were the same as for the selected seeds. The check occupied three beds. The table below shows the results obtained from the check.

TABLE II

RESULTS OBTAINED FROM THE CHECK

Average plant production

Plants				Pods			Seeds			
Height in cm.	Weight of veg. matter in gms.	No of pods	Weight in gms.	Size in cm.	Aver No. of seeds per pod	Size of seed in mm.	Weight of dry seeds in grms.	Weight per 100 seeds in gms	Average No. of branches	Length of longest stem
35.22	197	19	33.83	15.3×.77	15	6.23×5.39	24.89	9.96	3	38

In the following table the recorded yields from the selected plant and from the check are grouped to note the effect of selection thereon. The methods of computation was based on the average performance record of each of the selected plants, and the average individual performance of the check.

TABLE III

	Per Hectare	
	Seed Kilos	Vegetable matter Kilos
Yield obtained from the check.....	442.592	3502.069
Yield obtained from the selected plants.....	693.836	5153.552
Gain of the selected over the check.....	251.244	1651.483

From the above results, we conclude that selection increased the yield over that of the common stock, both in seed and in vegetable matter. This increase might be still more marked if only the exceptional plants are saved for further planting.

ADAPTATION OF COWPEAS TO SEASON AT THE COLLEGE OF AGRICULTURE

To find out the effects of excesive rain and drought, and so to determine the best seasons for cowpea culture in this locality, there are here brought together the results obtained from the present study, and those carried on by our Department of Agronomy, together covering a period extending back to September 1912.

TABLE IV

SHOWING VARIATIONS DUE TO SEASON

Variety and College Number	*Date of Planting*	*Date of Flowering*	*Date of Harvesting*	*Yield per hectare in kilos*		*No. of days from seed to harvest*
				Seed	*Green matter*	
Black.....	Sept. 16, 1912	Dec. 20, 1912	Jan. 14, 1913	1492.5		120
737.....	Dec. 6, 1912	Jan. 20, 1913	Feb. 15, 1913	703		71
606–F1....	Aug. 29, 1913		Nov. 1, 1913	1888		64
737–F1....	Oct. 7, 1913	Nov. 25, 1913	Dec. 20, 1913	258		74
606–F2....	Dec. 11, 1913		Feb. 10, 1914	1356.4		61
737–F2....	Aug. 14, 1914	Sept. 25-30, 1914	Nov. 20, 1914	3333.4	13010.9	87
737–F2....	Oct. 25, 1914	Dec. 8-15, 1914	Jan. 16, 1915	2060.8	6792.5	83
737–F3....	Dec. 1, 1914	Jan. 8, 1915	Feb. 15, 1915	693.8	5153.55	63

NOTE: Available records do not show the yield of green matter for the first four plantings shown by this table. Nos. 606-F1 and 606-F2 have no data respecting the time of flowering.

An examination of the preceding table shows that, on the whole, heavy yields both of seed and green matter were obtained in three different plantings in August, September, and October 1912, 1913, and 1914, respectively; which time partially covers the so-called wet season in this country. In the case of Nos. 606-F1 and 737-F1, however, the yields are contradictory. The former, planted December 11, 1914, gave a fairly good yield of seed, and No. 737-F1 which was planted October 7, 1913, yielded but little seed in comparison with the others that were planted at the same time of the year.

It is obvious that seasons and weather conditions have a pronounced effect, and a variety which has once produced good yield may turn out poor the next year, although planted at the same season, if weather conditions are adverse.

The following table shows the distribution of rainfall by months and the number of days of rain:

TABLE V

(*Compiled by* DR. F. C. GATES.)

Year	*Month*	*Precipitation in cm.*	*Days rained*	
1913..	June.....	5.86	8	Wet season
	July.....	40.69	27	
	August.....	22.15	28	
	September...	29.95	18	
	October.....	17.4	12	
	November...	10.09	16	Dry season
	December...	9.83	29	
1914..	January.....	1.55	8	
	February....	.914	4	
	March.....	.43	5	
	April.....	7.03	7	
	May.....	7.82	10	
	June.....	30.76	19	Wet season
	July.....	15.16	22	
	August.....	21.16	20	
	September...	69.70	20	
	October.....	5.91	16	Dry season
	November...	6.76	14	
	December....	5.54	16	

For these two years the average precipitation of the season beginning June 1913 to December 1914, are as follows:

Wet season ..128.40 cm.
Dry season.... 25.09 cm.

From this table, it appears that No. 737-F1 enjoyed during its life period but little precipitation, and the rain was distributed through many days. Such a condition is well known to be unfavorable for the cowpea. The plantings of September 1912, and of August 1913 and 1914, had the greatest yield. By again referring to the table, it will be seen that the last three plantings came from the cowpeas planted August 14, 1914, when in September following, the total precipitation was 68.10 centimeters. There was a start then, of more than two weeks before the crop received excessive rains. The cowpea is a tropical crop, and does

not withstand drought well. It is not adapted to regions where long drought is liable to occur, nor to regions with too many days of excessive rain.

It is evident, then, that no set rule can be laid down as to the most suitable season for the successful growing of cowpeas in this locality, but in general, it seems that the time best suited is from August to December. Planting earlier or later than this is not to be recommended, for, in either case, the plants become poor and exhibit a sickly condition.

Mr. Elayda of this College has informed the writer that according to his experience in this particular locality, the best condition for the cowpea is plenty of rain during the early development of the plant. When it has attained its full growth, or a height of 10 or more centimeters, more ground water is needed until the flowering period is reached. Too much rain immediately after planting gives the young plants abnormal growth and apparently makes them susceptible to disease. Plant lice, and maggots (*Agromyza* sp.) which attack the roots, are very common when the plants are young.

The time of maturity varies widely and is modified largely by the time of planting, and probably by the character of the soil and by the latitude. It has been noted in the United States that the bush varieties ripen sooner than the trailers, but a bush variety taken from the north, will, in the course of a few seasons, assume the trailing habit and lengthen out its period of growth in any of the Southern States.[3] A runner or creeper requiring six to eight months for reaching maturity in Louisiana will, if planted each year a hundred miles farther north, gradually accommodate itself to the shorter season and at the same time shorten its runners; approaching more and more to the upright "bush" habit of growth.[3]

Table IV shows that the length of time required in each planting from seed to harvest, except the Black variety which was planted September 16, 1912, ranges from 61 to 87 days. Obviously, those that were planted during the dry season and had less precipitation, mature earlier than those planted in the wet season; the reason being that dry weather tends to lessen the production of vegetable matter, to shorten the stem and branches and to hasten flowering, while the wet season causes the plant to produce a more viny growth, and thus delays maturity. The fruiting period is materially lengthened by the wet season, as is shown by the two plantings of August 14, and December 1, of 1914.

As compared with the reports of some of the leading cowpea states of the United States, these yields are fairly representative. On page 437 of Bulletin No. 172, Vol. XVII, March 1914, of the Purdue University, Indiana, are tabulated results of the test of varieties of cowpeas for hay production as follows:

RESULTS OF TESTS OF VARIETIES OF COWPEAS FOR HAY PRODUCTION
Average of Years 1903-1911

Variety	Yield of Hay.		Variety	Yield of Hay	
	Pound p. acre	Kilos p. Ha.		Pound p. acre	Kilos p. Ha.
B. P. I. No. 13,468	3294	3668.24	Lady or Galivant	3748	4207.99
Clay	4101	6063.85	Michigan Favorite	3953	4438.1
Early Black	4610	5175.8	New Era	4298	4825.4
Early Blackeye	4059	4557.15	Red Ripper	6461	6131.21
Extra early black eye	4400	4940.0	Taylor	4391	4929.9
Iron	4610	5175.8	Warren	4250	4771.1
Whipporwill	4289	4815.37	Wonderful	4671	5244.25

SUMMARY

1. Cowpeas, as existing in our cultures, are exceedingly variable in the characters and performance of individual plants.

2. The yield of cowpeas both for forage and for grain can be increased by selection of seeds in the field and by growing the selected seeds of one parent plant separately in test rows, afterwards planting to field in pure culture.

3. The New Era cowpea is the only variety that has proved a success on the College of Agriculture farm, and in neighboring private fields.

4. Cowpeas need to be improved by selection, as regards earliness of maturity, immunity to disease, evenness of maturity, uniformity of type, and above all, productiveness.

5. The best time for planting cowpeas in the region of Los Baños is from August to December.

6. Cowpeas produce large yields of vines and peas per unit area of land. These vines can be profitably used either as green manure, or stock food, and the peas can be used as human food.

7. As compared with the yields of both peas and vines of cowpeas in the United States, the cowpeas used in this work gave a fairly good yield.

ACKNOWLEDGMENT

The writer wishes to express his thanks to Professor C. F. Baker for his criticisms during the progress of this work.

BIBLIOGRAPHICAL REFERENCES

1. *Missouri State Board of Agriculture, Monthly Bull.*, Vol. X, No. 1.

2. *The Philippine Agriculturist and Forester*, Vol. I, Nos. 4-6.

3. *Year Book of the U. S. Department of Agriculture for* 1896, p. 286-296.

4. *Louisiana Experiment Station Bulletin* No. 40, 2nd Ser., p. 1441.

5. *The History of the Cowpea and its Introduction into America, Bulletin* 102, part VI.

6. *Commercial Products of India*, by Watt.

7. *Cyclopedia of American Horticulture.*

8. *Farmers' Bulletin* No. 318, *U. S. Department of Agriculture*, COWPEA, by H. T. Nielsen.

9. *Kansas Bulletin* No. 160, Department of Agronomy, April 1909.

10. *Year Book of the U. S. Department of Agriculture, for* 1898, p. 355-376.

11. *Cornell University Agricultural Experiment Station, Plant Biology, Bulletin* No. 251.

A Study of the Production of Peanuts

By Gaudencio Consunji y Tongco

Thesis presented for graduation from the College of Agriculture, No. 44

A demand in the Philippines for peanuts and for their products is demonstrated by the fact that there is a considerable importation of peanuts and peanut oil. In 1913, these imports were valued at ₱388,360. Peanuts are raised in tropical and warm temperate countries throughout the world. In America, they are grown from Virginia South, in Mexico, Columbia, Bolivia, Peru, Chile, and Porto Rico, and to a less extent, so that they do not appear in published statements of commerce, in the other warm countries. In Europe, only Italy, France, Portugal, and Spain produce peanuts as an article of commerce. In Africa, they are reported from Senegambia, Guinea, Senegal, and the West Coast. In the Orient, they are grown extensively in China, Japan, the Philippines, and Borneo. The yield varies greatly in different places; for example, under Japanese culture, the average yield near Yokohama was reported in 1907 as 68.09 bushels per acre, and in Formosa at the same time as 22.73 bushels. From the Porto Rico Agricultural Experiment Station, it is reported that a strain has been developed by selection which yields more than 90 bushels to the acre and is of superior quality.

There is considerable difference between varieties of peanuts, and in order that the local demand may be met economically by Philippine production, it is desirable that different varieties be introduced and carefully tested. Experiments to determine the proper spacing and proper use of fertilizers, irrigation and tillage should also be made as a basis for recommendation to the individual farmer. In the writer's work, the time has not been sufficient to carry any selection work to a finished conclusion; the study has therefore been confined to methods of production and to a testing of varieties. There has also been a preliminary selection which should be valuable as furnishing material for the more extensive work of the same kind.

Thirteen varieties, or supposed varieties, of peanuts have been obtained at different times and used in this work. For the first planting, April 16, 1914, two of the three varieties used were those already on the College farm, one called "American" and the other "Spanish." A third variety "was obtained" from Robert Seth & Co., Calcutta. Three additional varieties, "Native Lemery" from Lemery, Batangas, "Kinorales," from Samal, Bataan, and a Chinese strain were planted June 14, 1914. For the third planting, July 22, 1914, seven varieties obtained from the Bureau of Agriculture were used:—Big Japan, Improved Virginia, Native, Spanish-American, Spanish-Indian, Valencia, and Virginia Bunch.

Description of Varieties

The "American" is a creeping peanut, its lateral branches extending from 80 cm. to 120 cm. It has dark green foliage. The stem is tough, hard, and round, and very pubescent. The leaflets are elliptical, but narrowed toward the base. The margin is strongly ciliate. The pods are 4 cm. x 1.5 cm., with strong longitudinal ridges and shallow rugae, and contain one or two seeds. The plant takes 7 to 9 days to come up, and begins to flower 25 to 30 days later. It occupies the ground for about four months and one-half.

The Big Japan variety differs from the American in creeping closer to the ground, having lateral branches reaching as far as 160 cm., and smoother pods. It occupies the ground for six months.

The "Calcutta" differs from the "American" in that the stem and leaves are smaller and more pubescent, and the pods are only about one-half as large, with more distinct rugae. It almost invariably produces two seeds to the pod.

The "Chinese" is like the "American," except that the leaves are somewhat lighter in color, and the growth is higher.

The "Improved Virginia" differs strikingly from the "American" in that its pods are twisted in form and have prominent irregular longitudinal ridges and larger rugae. Its stem and leaves are rather larger. The Virginia Bunch is indistinguishable from the Improved Virginia.

The native variety obtained from the Bureau of Agriculture is a plant of compact growth with the stems generally errect and not very pubescent The leaves are like those of the "American" in shape and are dark green in color, and but slightly ciliate. The pods are mostly found close to the base of the main stem and are twisted like those of the Virginia; they contain two seeds each.

The Native Lemery is a much branched peanut, its lateral branches reaching from 90 cm. to 120 cm. The stem is strongly pubescent. The pods are long and slender with very distinct ridges and rugae, and containing three or four seeds, or rarely less.

The "Valencia" is a stocky plant of about five stems, each from 40 to 70 cm. long, scantily pubescent and purple in color. The branches grow at an angle of about 40° to the ground. The leaves are large and pale-green in color. The pods are 4.5 cm. by 1.2 cm. in size, with irregular ridges and shallow rugae, and contain three or four seeds which are dark red. This variety germinates in four to six days and flowers within a month. It occupies the ground for three months.

The "Kinorales" is a much branched plant, but does not form as dense a growth as the "Native." Its stem is angular, purple in color and scantily pubescent. The leaves are smaller than those of the "Valencia" and more numerous. The pods are 2.4 by 1.1 cm., longitudinally ridged and rugose, containing two dark red seeds.

The "Spanish-India" is very similar to "Kinorales," but the stem is only slightly pink, and the pods are rounded at the ends and constricted in the middle, and seeds are white. The "Spanish-American" and the Spanish varieties previously at the college, are practically identical with the Spanish India.

Culture

The soil for peanuts must be not too compact for good root development and for the young fruit to be forced below the surface, and must not be loose enough to dry badly or to encourage too deep production of fruit. Sandy loam is everywhere recognized as an excellent type of peanut soil. To be ideal, it must contain a reasonable amount of humus and abundant lime. It should be thoroughly prepared before planting in order that weeds may not choke the young plant. The thoroughness and depth of the preliminary cultivation which is desirable depend of course upon the season; when dry weather is to be expected, thorough cultivation is needed to conserve the water.

Plantings in the rainy season are made 100 cm. by 50 cm. for the dark-green varieties 80 cm. by 35 cm. for the varieties with light-green foliage, the latter producing less thrifty vegetation.

In the dry season, the spacing should be somewhat less, 90 cm. by 40 cm., for dark-green varieties, and 75 cm. by 35 cm., for the light-green. The seed may be planted either shelled or unshelled. The use of shelled seed permits more perfect selection of seed and results in quicker germination, but has the disadvantage that the seeds are more likely to be eaten by ants. To insure a full stand, if shelled seeds are used, three should be planted in each hill.

Peanuts require about the same cultivation as sweet potatoes. The first cultivation is likely to be needed when the plants are 10 to 15 days old. After this, the need depends upon the weather and upon the texture of the ground. It may be necessary as often as once in 15 days for the light-green variety, and once in 20 days for the dark-green. In general, two cultivations are likely to be needed for the light-green variety and three for the dark-green. Frequent cultivation favors both the development of the pods and the ease of harvesting.

In most peanut regions the crop is harvested by using a plow to break the soil and throw out the pods. If the weather has been dry and the soil is heavy clay, the harvesting operation involves considerable work, which may be made easier by using irrigation. In the *United States Department of Agriculture Farmer's Bulletin, No. 356*, special implements for harvesting peanuts are described.

The vines with the pods attached are removed from the ground and piled in the open to dry and cure. The light-green variety should cure in a week of favorable weather, and the dark-green variety after a somewhat longer time. After they are dried, the pods are easily removed and sorted.

To bring out contrasting estimates of the hectare production, based upon the production by individual plants, all the plants in a plot were carefully dug up, leaving no pods in the ground, washed hill by hill, numbered, and weighed in a canvas container of known weight as soon as the surface water of the pods was evaporated. All individual results from a plot were then divided into three equal groups, representing maximum, medium and minimum yields.

The first harvest was that of the supposed American variety, planted from April 15 to April 18, 1914. This planting was intermixed with very young bananas which were too small to shade the peanuts, but resulted in an irregular spacing; part of the plants were spaced 80 cm. by 45 cm., others 120 cm. by 55 cm. The following table is based upon weighing of individual plants by the method just described, but assumes a uniform spacing of 100 cm. by 50 cm.

Variety	*Col. No.*	*Generation*	*Maximum*	*Medium*	*Minimum*	*Average*
American..	109	F5	1,948	1,090	368	1,135.3

The average given in this table is that of the three preceding numbers, but is a proper average based on the culture because the three groups were of equal size. Assuming that peanuts in the shell weigh 26 pounds to the bushel, the average yield of this culture was at the rate of 38.4 bushels to the acre.

When this culture was harvested, it was found to be a mixture of two distinct strains. One of these was what was expected, and retained the name of American in subsequent cultures; the other strain was like Spanish varieties from other sources, and was given the name of Spanish C. A., and a new number, 3166.

Fertilizer Experiment

To test the effect of generally available fertilizers, use was made of ash and stable manure. The first experiment of this kind was with the Calcutta

variety planted April 20, 1914. A fuller series was planted May 14. All seed was from plants of previously determined productiveness. The cultivation of all plots was the same, as is also true of the irrigation. Water was applied six times. The result of this experiment is shown in Table I.

TABLE I

Comparison of Yield Calculated per Hectare as Affected by Ash and Manure in our Culture

		Variety Name	*American*	*American*	*Calcutta*	*Spanish C. A.*	*Spanish C. A.*
		College Number...	109 F6	109 F6	2703 F1	3166 F1	3166 F1
		Number of parent plant.....	29	230		453	33
		Yield of parent plant in grams of pod.....	82	87		42	41
Calculated crop per Hectare.	Check.....	Whole plant.....	33464	34630	35532	11438	12686
		Pods.....	8664	10702	7662	3820	4673
	With ash....	Whole plant.....	35966		43984		14763
		Pods.....	9277		10473		
	Stable manure	Whole plant.....		48237	86011	20512	
		Pods.....		14777	14681	6611	
Percent increase	With ash....	Whole plant.....	7.5		23.8		16.3
		Pods.....	7.3		36.7		16.9
	With manure	Whole plant.....		39.0	142.1	80.2	
		Pods.....		38.1	91.5		

Spacing of Plants

The effect of planting at different distances was tested with three varieties: Kinorales, Native Lemery and Chinese, planted July 16, 1914, and spaced as follows:

Kinorales.....80 cm.×35 cm., 100 cm.×40 cm., and 110 cm.×45 cm.
Native Lemery.80 cm.×35 cm., 100 cm.×40 cm., 110 cm.×50 cm., and 120 cm.×30 cm.
Chinese .....80 cm.×35 cm., 100 cm.×40 cm., and 120 cm.×30 cm.

The "Kinorales" was harvested November 30, 1914, the "Chinese," November 16, 1914, and the "Native Lemery," January 19, 1915. These plots were cultivated and weeded three times. Preliminary to harvest, the ground was heavily watered and left over night to soften it. Computations based on the result of this culture are shown in the following table.

TABLE II

Calculated Yield per Hectare

Variety Name and Number	*Spacing*	WHOLE PLANT			NUTS			AVERAGE	
		Maximum	*Medium*	*Minimum*	*Maximum*	*Medium*	*Minimum*	*Whole plant*	*Nuts*
Native Lemery....	80×35	13,211.25	8,859.90	4,854.3	3,300.2	2,539.6	1,439.6	8,975.15	2,426.46
3082 F1.....	100×40	15,482.5	9,730.	6,166.2	4,610.46	3,373.87	3,386.20	10,459.56	3,386.20
Native Lemery...	110×45	14,585.27	10,549.47	6,285.68	3,273.83	2,203.88	1,809.90	10,473.47	2,429.20
Native Lemery...	120×50	8,552.08	5,320.08	3,581.9	2,775.56	1,832.6	1,332.8	5,818.02	1,980.32
Kinorales.....	80×35	11,958.56	9,454.89	5,807.96	3,229.66	2,544.37	1,950.68	9,073.80	2,574.90
3083 F1.....	100×40	9,455.	6,250.	4,592.5	3,232.5	2,207.5	1,375.	6,765.83	2,271.66
Kinorales.....	110×45	8,639.56	5,999.7	3,998.8	2,299.88	1,573.92	1,073.94	6,213.02	1,649.24
Chinese.....	80×35	16,141.51	9,102.07	5,343.18	4,749.50	3,005.75	1,967.65	10,195.58	3,240.96
3084 F1.....	100×40	14,850.	11,350.	7,842.50	5,522.5	4,165.	3,000.	11,347.50	4,229.11
Chinese.....	120×50	10,557.44	7,788.55	5,331.20	3,498.60	2,727.24	1,915.9	7,892.39	2,713.91

With the seven varieties last received, a comparative test was made on trial plots with the result shown in Table III.

TABLE III

COMPARISON OF YIELD PER HECTARE OF SEVEN VARIETIES

Varieties		*Big Japan*	*Virginia Bunch*	*Improved Virginia*	*Native*	*Spanish India*	*Valencia U.S.A.*	*Spanish U.S.A.*
Planted		July 23	July 24	July 23	July 23	July 23	July 23	July 23–1914
Above ground		July 30	July 30	July 30	July 30	July 30	July 30	July 30–1914
Flowered		Aug. 24	Aug. 24	Aug. 24	Aug. 24	Aug. 20	Aug. 19	Aug. 20–1914
Harvested		Jan. 13-15	Nov. 29	Nov. 29	Nov. 29	Nov. 28	Nov. 28	Nov. 28–1914
College Number		3079	3075	3081	3080	3078	3076	3077
Generation at the college		F1	F1	F1	F1	F1	F1	F1
Whole plant.	Maximum	14,840	11,300	9,162	6,500	6,650	6,382	5,750
	Medium	8,680	7,416	6,786	4,700	5,650	4,582	3,750
	Minimum	4,420	4,540	4,674	2,350	3,150	3,132	2,800
Nuts	Maximum	3,624	3,650	30,070	2,400	1,500	1,500	1,800
	Medium	2,550	2,382	2,250	1,800	1,110	1,100	1,200
	Minimum	1,824	1,566	1,446	1,000	700	700	600
Average	Whole plant	9,313	7,752	6,874	4,517	5,150	4,699	4,100
	Nuts	2,666	2,533	2,255	1,733	1,103	1,100	1,200

Tillage, irrigation, the use of fertilizers and proper spacing can, of course, only make the individual plants produce as much as the inherent nature of the individuals permits. In every variety tested, there was found a wide variation in the productiveness of the individual plants. It has already been noted that, in the course of this work, plants were selected as the parents of future strains from which an increased average productiveness is anticipated. At the time of writing, it is already evident that these hopes will, to a considerable extent, be realized.

Finally, even though all cultural methods are what they should be, and the strains used are of selected productiveness, the work may still be vain, if the crops fall a prey to their organic enemies. In the course of these experiments, considerable damage has been done by termites and by rats. In every culture, some injury was done by the fungus, *Cercospora personata*; the Valencia variety was most susceptible to this disease, followed by the Spanish and Chinese. In general, plants with dark green foliage were more resistant than those of the light green type. Close planting and wet weather favor the development of this disease.

CONCLUSIONS AND RECOMMENDATIONS

1. Peanuts are worth raising in all parts of the Philippines and at all seasons, for the sake of the nuts and of the oil as well as for livestock, and to improve the soil.

2. The difference between individuals is so great that the seed for planting should always be carefully selected, paying primary attention to the productiveness of the parent plants.

3. As catch crops in young plantations, the varieties recommended are the American, Chinese, Big Japan, Virginia Bunch, Native Lemery, and Improved Virginia; in older plantations, the Spanish varieties are recommended.

4. As a cover crop, the Improved Virginia is especially recommended.

5. For the production of forage, the dark green varieties are recommended, and the application of manure is especially beneficial in raising crops for this purpose.

6. For making hay, Spanish varieties are recommended, as their leaves are thin and do not touch the ground, wherefor the vegetation is easily cut and cured.

7. If the crop is to be marketed in the form of nuts, the Chinese variety is recommended.

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Abaca Fiber

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Introduction

In view of the fact that abaca is so important and valuable a product, and a natural monopoly of the Philippines, it is surprising that so little study has ever been given it.

The fiber exported for cordage purposes is obtained from the outer layer of the leaf sheath. This fiber is somewhat woody in structure, of a bright yellowish-white color, possessing great durability and strain-resisting power. It consists of bast fiber, parenchyma cells, and a few vessels with one or two spiral bands. The fiber[3] produced from the inner layers of the leaf sheath is fine and relatively weak, but it is of great value to the natives of the Philippine Islands for making a fine cloth of high grade.

In cross-section,[2] the cells constituting a fiber are polygonal in shape with rounded corners and rounded lumen. Some cells have thin walls and large lumen; others have relatively thick walls but narrow lumen. Hanausek[2] found that the bast cells vary in breadth from 12 to 40 microns (0.012-0.040 mm.) but the greater number are from 21 to 30 microns; with smooth thin walls and uniform lumen. The cells have a diameter of from 3 to 4 times the thickness of the wall, and sharp or pointed ends. The fiber element, however, was found by Matthews to be from 3 to 12 mm. long, and from 0.016 to 0.032 mm. wide. The ratio of the length to the diameter is about 250.

Matthews [1] states that when the fiber is treated with iodine and sulphuric acid or with anilin sulphate, the cell walls become golden yellow to green in the former, and yellow in the latter, which changes indicate that the cell walls are lignified. Caustic soda colors the fiber a faint yellow and causes slight distension: ammoniacal copper oxide produces a blue color and a considerable swelling.

Hanausek [2] asserts that the fiber of Manila hemp closely resembles that of New Zealand flax, pita, and sisal hemp, differing from the New Zealand flax in the character of the lumen, and from the others in the ends of the fiber. Manila hemp differs particularly from any of these fibers by the presence of the so-called stegmata, which are strongly silicified tabular cells. Moreover, Manila hemp differs from sisal [1] in the color of the ash, which is grayish black in Manila hemp, and white in sisal.

The Plant

Stem.—Dissection of a plant about to flower shows that the length of the internodes decreases as the youngest leaf or the growing point of the shoot is approached. A cross-section of the young stem shows that the vascular bundles are scattered in the pith or central cylinder—a characteristic of monocotyledonous stems. Immediately within the epidermis no sclerenchyma strands are present; they begin usually at a depth of five layers of parenchyma. Strands nearest the epidermis exhibit neither vessel nor thick-walled cell. Some of the large vascular bundles have at least one large spiral or annular vessel with large ovate or circular lumen. Others exhibit a more or less circular intercellular space. Longitudinal section near the tip or the growing point of abaca shoot shows that spiral vessels exist as high as the seventh from the youngest internode of the stem, but there are no definitely clear bundles from the youngest internode to the

seventh, inclusive. In the two youngest internodes, the cells are more or less rectangular and, in some cases, square in shape and full of protoplasm, and each contains a conspicuous nucleus. Some cells, however, a little farther from the tip, are pentagonal in shape. Starch grains are found in abundance in the young part of the stem.

The dissection of a trunk of fruit-bearing abaca and the measurements of the length of the internodes of the true stem from the top to the bottom of the trunk gave the results recorded in the following table:

TABLE I

	Length of internodes in cms.	*Height from cutting point in meters.*
1. Uppermost	112.0	3.95
2.	100.0	2.83
3.	85.0	1.83
4.	45.0	.50
5.	22.0	0.45
6.	7.5	0.24
7.	5.0	0.165
8.	3.5	0.115
9.	2.5	0.080
10.	2.0	0.050
No more can be measured		
	384.5 cm.	

The trunk was about 4 meters high, and 50 cm. in circumference at one meter from the cutting point.

The above figures show that the length of the internode increases as the top of the stem is approached. Leaf sheaths attached to nodes one-half meter or more high are not of much value commercially, because they have much shorter and weaker fibers than those attached to the lower nodes and make trouble for the stripper.

The stem decreases in size from about 25 cm. in circumference at the cutting point to about 11 cm. in circumference at the middle of the stem, and, thence upward, the size increases gradually to 14 cm. in circumference at the last node, 3.95 meters high.

Upon dissecting a plant not yet in flower, it was observed that the very young leaves are funnel-shaped and entire, like those of the coconut; but there is no obconical depression on the tip of the stem (growing point) after all young leaves have been removed, but rather a conical projection. As in the coconut, the growing point of the leaves, and of the stem as well, is protected by many overlapping leaf sheaths.

The Leaf Sheath

A cross-section of the false trunk of abacá (Plate I, Fig. 1) shows that it is formed by overlapping leaf sheaths. The center of the trunk, when it is fruiting or about to fruit, is the stem, but when it is not yet near fruiting the place of the stem is occupied by two or three young leaf sheaths, and sometimes a rolled lamina is present in the center. These structures have altogether a circumference about as large as that of the stem. Immediately after cutting across the trunk, these project out of the rest of the sheaths so rapidly that the movement is visible with the naked eye. This is due to the fact that the interior leaf sheaths are held back in their growth, and that the strands that these leaf sheaths contain are under compression. After all the outside leaf sheaths that can be stripped are removed, the two or three remaining ones are very tender and can be broken very easily. Examination of cross-sections of these sheaths shows that the walls of the cells composing the strands are still thin. The outermost leaf sheath is the oldest and the most discolored; the succeeding ones, perhaps nine in number, are somewhat discolored, while the remaining inner and younger leaf sheaths are colorless.

The leaf sheath marked X in Plate I, Fig. 1, was separated from the trunk and a diagram of the cross-section of it was made (Plate I, Fig. 2). The figure shows that fiber strands as well as the

vascular bundles are scattered well throughout the sheath. Leaf sheaths may be detached from the trunk and split into pieces 4 to 6 cm. wide. Then the pulpy inner part of each piece is removed before passing it through the machine. Or, beginning at the upper end of the sheath before it is removed from the trunk, the leaf sheath may be divided longitudinally into pieces about 4 to 6 centimeters each in width. The two portions from the edges of the sheath are first pulled off and put aside. Then each portion from the middle part of the sheath is bent outward and pulled downward. If this is well done, the outer part of each strip, shown by letter N in Plate I, Fig. 2, will be pulled off by itself, leaving behind that portion of the middle part of the sheath which contains no valuable fiber but rather large vascular bundles with weak bundle sheaths (Plate I, Fig. 2-K). The remaining inner part of the sheath is then pulled off and thrown away. The preliminary separation of the portion shown by the letter N from that portion indicated by K is to save the stripper from the difficulty of pulling the waste part through the machine, and to save some good fiber which might go with the discarded portion of the sheath. The bands from the edge of each sheath and those from the outer layer of the middle part (N) are, in practice, not kept apart in stripping; this might well be done, though, for the sake of careful grading.

Fibers from different leaf sheaths of a mature plant, 4 meters high and 50 centimeters in circumference at one meter from the cutting point, were stripped out; the fiber from the inner nine leaf sheaths was fine and white. Fibers from the outer leaf sheath were coarser and were more difficult to strip than fibers from the inner sheaths. The difficulty in stripping out the fibers from the outside leaf sheaths is probably due to developed parenchyma cells attached to the fibers and may also be due to the presence of stegmata which make the surfaces of the fiber rough, thus causing friction in stripping. Fibers obtained from perhaps nine inner sheaths of a trunk should be separated from the fibers obtained from the outside sheaths of the same trunk. The former can be used as fine materials for textile purposes, whereas the latter are good for cordage.

Another point of some importance is the brittleness of the fibers while yet in the sheath. Perhaps five outside leaf sheaths on a trunk contain fibers which are more brittle than those yielded by the succeeding inner leaf sheaths. This condition is probably due to the presence of a great quantity of stegmata. Precautions should therefore be taken not to split the leaf sheath carelessly, nor should the piece be pulled through the machine when it is rolled or twisted or bent. It is practicable to place a plank or a piece of board on which the piece to be pulled through the machine may slide.

All leaf sheaths of an abacá about to bear flower yield fiber, except the two or three youngest ones. Allowing the plant to bear flower, these young leaf sheaths will develop good fiber for textile purposes. The younger the plant is cut the more sheaths will be lost which might, if given time to, develop into useful fiber. On the other hand, if the plant is allowed to remain long after flowering, the usual tendency is that the outer sheaths decay, beginning at the top and spreading downward.

The proper time to cut the trunk is immediately before or after the inflorescence appears. This is the general native understanding, and was confirmed by the fact that the average amount of fiber obtained from two large trunks about to flower under shade was

455.27 grams; whereas, two large old fruiting trunks from the same hill gave an average of only 285.97 grams. Two large trunks about to flower, in a lot exposed to the sun and neglected, yielded an average of 196.43 grams of fiber, while two large fruiting trunks from the same lot gave an average of only 86.39 grams of fiber.

A trunk of average size, 298 centimeters high, and 48 centimeters in circumference one meter from the cutting point, produced leaf sheaths whose width increased gradually from the oldest, outermost sheath, 16 centimeters wide (at the same height), to the leaf sheath about half way from the outside to the center of the trunk, 17.5 centimeters wide; but thence inward, the width of the sheaths decreased gradually to the innermost leaf sheath which was about 10 centimeters wide. The whole trunk produced a little over 490 grams of fiber or slightly less than half a kilo. The amount of fiber produced from each leaf sheath increased gradually from nearly 10 grams obtained from the outermost leaf sheath, to about 43 grams from the widest leaf sheath, and thence inward the amount of fiber produced by each leaf sheath decreased to the innermost leaf sheath, which yielded 12 grams. The number of leaf sheaths that could be stripped for fiber ran as high as twenty, and even more in some cases; but a twenty-sheath trunk 4 meters high is fairly large.

Before treating the anatomy of the leaf sheath, it is desirable for the sake of clearness to define some terms which will be met with in the discussion. In this paper, the expression "sclerenchyma strand" will be applied to all strands composed of sclerenchymatous cells; the "fiber strand" is a sclerenchyma strand which has no conducting tissue; the "bundle sheath" is the sclerenchyma strand annexed to a vascular bundle; the "air spaces," Plate I, Fig. 2, are the large intercellular spaces in a leaf sheath; and the "bridge," the solid portion of the leaf sheath between two air spaces and connecting the outer and inner solid parts of the leaf sheath.

The cross-sections of the different leaf sheaths of a trunk, cut at the same height, show that the leaf sheaths have fiber strands and vascular bundles of different sizes. Each strand from the outer leaf sheath is larger in cross-section than the corresponding strand from the succeeding inner leaf sheath. In a single leaf sheath, however, the largest cross-section of the strand is at the base of the leaf sheath, whence there is an abrupt decrease in size of the strand, in cross-section, to about 50 centimeters higher (Plates II, III, and IV).

The outer epidermis of a leaf sheath is composed of a layer of cells, the outer walls of which are thickened. Some fiber strands are directly attached to the epidermis; others are separated by one layer of parenchyma from the epidermis; but there are usually two or three layers of parenchyma before any fiber strand is reached. Epidermal cells are sometimes found attached to fibers in marketed abaca. These epidermal cells color the fiber and consequently lower its grade.

The cross-sections of the fiber strands near the outer epidermis of the leaf sheath (Plate I, Fig. 2-E; Plate II, Figs. 1-5; Plate III, Figs. 1-8; Plate IV, Figs. 1-6 and Plate V, Fig. 1-2) show the smallest fiber strand to be composed of only four cells. Other fiber strands have from five to over forty cells each. The cells are provided with thick and lignified walls. The lumina of the cells are, as a rule, narrow and have rounded corners. Contrary to the observation of other students of the subject, no content in the lumen was seen in the thousands of fiber cells examined by

myself. The cross-section of the strand is rounded or more or less oval in shape. Under normal conditions, all fiber strands can be stripped from the outer part of the leaf sheath; usually they are entire.

A little farther inward from the outer epidermis, as shown by Plate I, Fig. 1-B, Plate II, Figs. 6 and 7, and Plate IV, Fig. 7, there are found some sclerenchyma strands, each of which has some conducting tissue which must be phloem. Eosin solution will not run upward through this tissue. Two sclerenchyma strands of similar nature, found at the base of the leaf sheath, shown in Plate IV, Fig. 8, show, beside the conducting tissue previously observed, some spiral bands characteristic of tracheae. It can be concluded therefore that smaller strands have only phloem, whereas larger strands have both phloem and xylem.

In the edges of the leaf sheath, as shown in Plate I, Fig. 2, the air spaces are much smaller than in the middle portion of the same sheath. Within one inch of the edge, no sclerenchyma strand is found under the inner epidermis. Inside the outer epidermis, at the edge, there are some fiber strands whose constituent cells have thick walls and comparatively narrow lumina (Plate V, Figs. 2 and 3, from Plate V, Fig. 1-A and B). The largest vascular bundle from the edge of the sheath is usually smaller than the smallest vascular bundle that has both xylem and phloem structures, in the middle part of the leaf sheath (Plate V, Fig. 4, from Plate V, Fig. 1-C).

The Manila hemp of commerce is composed of fiber strands as well as sclerenchyma strands that have some conducting tissue. Besides these structures, Manila hemp may have also bundle sheaths, either entire or in pieces obtained from the edge of the leaf sheath; and occasionally fragments of bundle sheaths from the internal part of the middle portion of the leaf sheath, are present (Plate V, Figs. 5, 6, and 7).

The largest vascular bundle (Plate IV, Fig. 12) in a leaf sheath is situated in the bridge (Plate I, Fig. 2-H). It has, in some cases, two sclerenchyma strands, but in others, it has only one sclerenchyma strand and this is annexed to the phloem. This strand is composed of sclerenchymatous cells whose gross diameter is usually larger than that of any sclerenchyma cell from other strands at equal height in the same sheath. The thickness, however, of the walls of the cells is less than in other sclerenchyma strands.

Between the bridges and the inner epidermis, or the portion of a sheath which we might call "discarded portion," there are a few vascular bundles (Plate IV, Figs. 9 and 10) about the size in cross-section of the larger fiber strands. These vascular bundles in some cases are accompanied by sclerenchyma on the outer (phloem) side alone, and in others with two sclerenchyma strands in each bundle (Plate III, Fig. 15). The sclerenchyma cells in a bundle vary in number; the two vascular bundles reproduced in Plate IV, Figs. 9 and 10, show twenty-one sclerenchyma cells in one, and thirty-eight in the other. The vascular bundles in the internal portion of the leaf sheath, will conduct eosin solution to the lamina. With the possible exception of the large vascular bundles in the internal part of the leaf sheath, the function of all of these bundles, besides the little mechanical strength they contribute to the trunk, is the transportation of water and food.

In the "discarded portion" of the leaf sheath, there are but few very small fiber strands (Plate III, Fig. 13). Sclerenchyma strands with phloem in each, are also present (Plate III, Fig. 14).

Eosin solution will ascend to the top of an old leaf sheath without lamina but with green in the upper part.

The Fiber Elements

Previous work on abacá fiber has been confined to fiber from the market, without regard to the part or parts of the leaf sheath which produced it. Because there is actually a material difference in the fiber cells, as well as in the strands, from different parts of the sheath, my work has been as largely as possible with strands extracted by myself, with care at all times to know their exact place of origin.

The method of maceration of fiber used in this experiment was very simple. A fiber from a known part of a leaf sheath was rolled and placed in an evaporating dish. A few crystals of potassium chlorate were dropped into the dish, and from 3 to 5 drops of concentrated nitric acid were added. The dish was heated until thick white fumes were evolved. The contents of the dish were then immediately transferred into a vessel containing water. Precaution must be exercised not to overboil the specimen, lest the cells themselves be partly or completely dissolved. The fiber was then transferred into another vessel of water. A few broken pieces were placed on a slide, and with the use of dissecting needles, the cells were separated and spread on the slide. The gross diameters of ten cells were measured under the microscope, and the length of each cell determined. The unit of measurement used is the millimeter.

The fiber cells vary in size and in length. The largest diameter is found at the middle of the cells; towards both ends it decreases gradually to somewhat pointed ends, which in some cases are provided with thick walls. The thickness of the walls also decreases gradually as it comes to the tips. This

TABLE II

Dimensions of Fiber Cells from Different Parts of Leaf-Sheath.

Lengths are stated in millimeters; Diameters, in ten-thousands of a millimeter.

		1	2	3	4	5	6	7	8	9	10	*Average*
A	Gross diameter.....	144	112	120	130	128	140	160	136	100	100	127
	Diameter of lumen..	46	22	30	46	46	44	60	44	30	30	40
	Thickness of wall...	49	45	45	42	41	48	50	46	35	35	44
	Length in mm.....	3.15	2.91	2.42	3.53	3.35	3.75	3.28	3.65	2.46	3.10	3.16
B	Gross diameter.....	160	136	180	124	112	140	138	160	190	184	152
	Diameter of lumen..	20	16	44	16	14	40	20	28	52	40	29
	Thickness of wall...	70	60	68	54	49	50	59	66	69	72	61
	Length in mm.....	4.00	3.84	8.96	3.44	4.17	2.75	5.18	4.71	4.44	8.45	4.992
C	Gross diameter.....	194	208	180	186	186	230	260	220	226	256	214
	Diameter of lumen..	120	140	120	116	116	150	180	120	146	160	137
	Thickness of wall...	37	34	30	35	35	40	40	50	40	48	40
	Length in mm.....	6.96	5.86	8.03	6.95	6.04	7.03	7.40	7.10	6.86	7.33	6.956
D	Gross diameter.....	142	200	180	180	122	170	220	180	156	240	179
	Diameter of lumen..	80	100	62	80	50	72	100	112	50	108	81
	Thickness of wall...	31	50	59	50	36	49	60	34	53	66	49
	Length in mm.....	2.86	4.86	6.47	5.57	5.50	4.36	5.54	3.06	5.73	7.45	5.14
E	Gross diameter.....	160	200	124	246	182	136	240	230	230	220	187
	Diameter of lumen..	70	74	50	90	70	60	80	100	94	72	76
	Thickness of wall...	45	63	37	28	56	28	80	65	68	74	55
	Length in mm.....	5.36	7.05	3.83	5.60	3.75	4.50	5.90	3.70	4.50	7.15	5.134
F	Gross diameter.....	234	276	280	170	244	260	220	230	360	270	254
	Diameter of lumen..	114	154	240	108	160	232	144	124	260	150	169
	Thickness of wall...	60	61	20	31	42	14	38	53	50	100	43
	Length in mm.....	7.20	5.39	7.03	3.15	4.13	5.32	5.82	5.73	8.34	4.43	5.654

is the reason, besides the fact that size of cells may vary somewhat in a single sclerenchyma strand, that in a cross-section of a strand some cells are large, others small, and some have slightly thicker walls than others.

The preceding table (Table II) shows the results obtained from this examination. A (Plate V, Fig. 8), stands for the fibers obtained near the epidermis 1 inch from the edge of the sheath; B (Plate V, Fig. 9), the fibers from the edge; C (Plate V, Fig. 10), from the discarded portion; D (Plate V, Fig. 11), from about the second row of sclerenchyma strands from the epidermis, at the middle part of the leaf sheath; E (Plate V, Fig. 12), from nearest the epidermis at the middle part of the sheath; and F (Plate V, Fig. 13), fibers obtained from the internal part of the leaf sheath, which in stripping is thrown away as waste.

The figures in this table show that the maximum diameter of cell was 0.036 mm. obtained from the big vascular bundle from the internal part of the leaf sheath, a portion of the plant which often goes with the waste in stripping. The minimum diameter was 0.01 mm., from the fiber obtained near the epidermis one inch from the edge of the sheath. The maximum diameter of lumen of cell was 0.026 mm. obtained from the big vascular bundle from the internal portion of the leaf sheath. The smallest diameter, 0.0014 mm., was found at the edge of the leaf sheath. The maximum thickness of cell walls was 0.008 mm., from the strand nearest the epidermis at the midrib. The minimum, 0.0014 mm., was found in the big vascular bundle from the internal portion of the leaf sheath. In the majority of instances, it was found that the fiber cells obtained from either the portion thrown away before stripping, or in the internal portion of the leaf sheath, exceed in length the fiber cells obtained from other parts of the same leaf sheath. However, it was twice observed that the fiber elements from the edge of the leaf sheath were the longest of all; these were 8.96 mm. and 8.45 mm.

In order to understand better and more clearly the preceding table, the following table of averages has been constructed:

TABLE III

Average Dimensions of Cells

	Gross diameter	*Diameter of Lumen*	*Thickness of Wall*	*Length*
A. Near the epidermis one inch from edge	0.01270	0.00398	0.00436	3.160
B. From the edge of leaf sheath	0.01524	0.00290	0.00617	4.992
C. From discarded portion	0.02145	0.01358	0.00389	6.956
D. About Second Row of Sclerenchyma from epidermis	0.01790	0.00814	0.00488	5.140
E. Nearest the epidermis at the middle portion of the leaf sheath	0.01868	0.00760	0.00554	5.134
F. Inner part of leaf sheath	0.02544	0.01686	0.00429	5.654

This table shows that fiber cells from the discarded portion of the leaf sheath had an average length of 6.956 mm., this being the longest shown in the table of averages. The shortest was 3.16 mm., from near the epidermis one inch from the edge. The largest average gross diameter of fiber cell was 0.02544 mm., this fiber being stripped from the internal part of the leaf sheath; the smallest average diameter was 0.0127 mm., from near the epidermis one inch from the edge. The diameter of lumen is correlated with the gross diameter

of the fiber cell. The widest average diameter of lumen was 0.01686 mm., from the internal part of the sheath. The narrowest average diameter of lumen was 0.0029 mm., from the edge of the sheath. The maximum average thickness of the wall was 0.00617 mm., from the edge of the sheath; the minimum, 0.00389 mm., was found in the discarded portion of the sheath.

From a study of the relation between the thickness of the wall and the diameter of the lumen on the one side, and the strength of the fiber on the other, it can be concluded that thick-walled sclerenchyma strands are, in general, much stronger than thin-walled sclerenchyma strands. For example, fibers from the edges are found to be about 10.08% stronger than those from the middle portion of the sheath.

Another proof that thin-walled sclerenchyma strands are weak is the fact that bundle sheaths of big vascular bundles from the internal portion of the sheath are as a rule very weak. In practice, the portion of the leaf sheath containing these bundle sheaths either goes with the waste portion in stripping, or is removed from the sheath before stripping begins.

Long-celled sclerenchyma strands were found to be weaker than the short-celled ones. But the short-celled strands are provided also with thicker cell walls than the long-celled ones. It is therefore difficult to draw a definite conclusion as to the relation between strength of fiber and the length of the cells composing it. It is a general belief that short-celled fibers are weaker than the long-celled ones, if all other conditions are the same.

Strength of Fiber

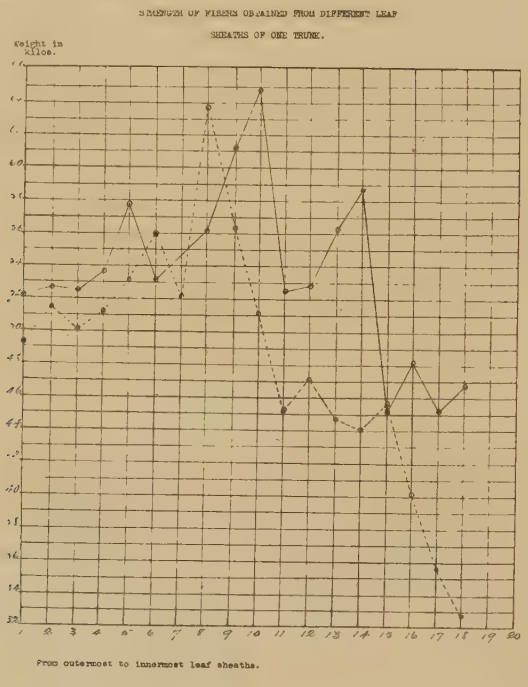
A comparative study was made of the strength of fiber obtained from different leaf sheaths of the same trunk. Eight fibers of average size, 60 cm. long, were used for each test, and for each sheath a test was made of fiber from the edge and the middle portion.

The apparatus used was of very simple construction, but it gives fairly accurate results when proper precautions are taken. This apparatus was made of two iron stands set on a fixed or immovable box, the two upper ends of the iron stands being connected by means of a horizontal iron bar. At the middle part of this bar, a clamp was fixed to hold the upper end of the fiber. Another clamp to which a weight was attached held the lower end of the fiber. On the upper end of this clamp, to measure the stretching of the fiber, was attached a piece of paper graduated into millimeters and half millimeters. At the start of the trial, the lower end of the scale is placed exactly opposite a fixed horizontal line. If weights are hung to the lower clamp, the scale will indicate the stretching. In these experiments, sets were discarded if the fibers broke at either clamp and if they did not break at the same time. Only the results, therefore, from sets the fibers of which broke about the middle part and at the same time were utilized to construct the following table. Great precaution was observed that no current of air interfered with the experiment.

TABLE IV

STRENGTH AND THE STRETCHING OF FIBERS OBTAINED FROM DIFFERENT LEAF SHEATHS OF ONE TRUNK

Sheath	Edges				Middle Portion			
	Stretching	*Breaking weight*	*Weight of sample*	*Strength calculated to gm. basis*	*Stretching*	*Breaking weight*	*Weight of sample*	*Strength calculated to gm. basis*
	mm.	gms.	gms.	Kgms.	mm.	gms.	gms.	Kgms.
1	12	6256	0.12	52.133	11.5	7416	0.14987	49.483
2	9	6367	0.1209	52.704	12	7767	0.1503	51.676
3	10	6367	0.12022	52.663	12	8515	0.1702	50.029
4	14	6442	0.11986	53.737	12	8617	0.1697	51.367
5	12.5	6487	0.1102	58.865	16	10667	0.2000	53.365
6	13	7972	0.15	53.147	14	9547	0.16974	56.245
7	8.5	5367	0.11032	48.649	10	9399	0.1804	52.100
8	11.5	8405	0.15	56.033	14.5	11477	0.1800	63.781
9	14	7964	0.13	61.261	13.5	11055	0.19572	56.483
10	13	9777	0.15086	64.801	12.5	10769	0.21026	51.168
11	8	6859	0.13072	52.470	12	8616	0.19032	45.271
12	9	6388	0.12054	52.994	8.5	7114	0.15078	47.247
13	8.5	6238	0.11088	56.259	12	7642	0.1704	44.847
14	13	6488	0.11068	58.619	10.5	7103	0.16036	44.292
15	9	6762	0.1498	45.147	8	6864	0.15034	45.656
16	9	3987	0.0804	48.345	9	5496	0.13672	40.198
17	8	3655	0.0807	45.266	8	4305	0.12044	35.743
18	6	1891	0.04062	46.555	7.5	3558	0.10843	32.813
Average				53.313				48.431


STRENGTH OF FIBERS OBTAINED FROM DIFFERENT LEAF SHEATHS OF ONE TRUNK.
Weight in kilos.
From outermost to innermost leaf sheaths.

Solid line ———— edges.
Broken line ..... middle part.

The above table shows that fibers obtained from the intermediate sheaths of an abaca trunk are stronger than those either from the outside or from the innermost sheaths. This is probably because the excessive amount of stegmata in the fiber from the outside sheaths makes the fiber brittle, and the lack of well developed walls of the cells composing the strands from the innermost sheaths make the fiber weak. It is calculated that one gram of the strongest fiber, 60 cm. long, taken from the edge, requires 64.801 kilograms of

weight to break it; the weakest fiber under the same condition requires only 45.147 kilograms. The average strength of fiber from the edge is 53.313 kilograms to a sample of one gram 60 cm. long. Fiber from the middle part of a sheath under the same conditions was found to be weaker; the maximum and the minimum strength being 63.781 kilograms, and 32.813 kilograms respectively; and the average strength 48.431.

The average strength of fiber from the edge was 4.882 kilos, or 10.08%, stronger than that from the middle part of the leaf sheath.

There are occasional striking irregularities in the amount of fiber stripped from successive sheaths. For example, Plant II in Table VI yielded from Sheath No. 6, 32.12 grams; from No. 7, 26.8 grams; and from No. 8, 31.62 grams. When the strength of these fibers was tested, it was found that the strength calculated on a gram basis, of the fiber from the edge of the No. 6 was 53.147; of No. 7, 48.649 kilos; and of No. 8, 56.033 kilos. The corresponding figures for the middle portion of the sheaths are: from Sheath No. 6, 56.245 kilos; Sheath No. 7, 52.1 kilos; and Sheath No. 8, 63.781 kilos. The smaller yield of stripped fiber from Sheath No. 7 is obviously due, at least in part, to the fact that its fiber is weaker, and so more likely to be lost in stripping. For the weakness, in turn, there are several possible explanations. Of these, the most likely is that the leaf was injured while young, and was, therefore, unable to supply the plastic material for the formation of much and strong fiber.

An attempt was also made to study the stretching of abaca fiber; but because of the diversity of figures obtained, no general conclusion can be drawn. When eight fibers, 60 centimeters long, were used for a test, 14.5 millimeters was the maximum stretching. Using a smaller number of fibers of the same length, the stretching was progressively greater. Of the ten trials made, 23 millimeters was the average stretching of sets of two fibers 60 centimeters long. And with one fiber of the same length, 27 millimeters stretching was the average.

Sun and Shade

An attempt was made to compare the fiber-producing power of two lots of abacá, both grown with good care as to cleanness, but one lot exposed to sun and wind, and the other grown under shade with little wind. The plants stripped were younger than are stripped for the market, but the observations on them may indicate their relative power of producing fiber.

TABLE V

Sun and Wind

Plant	Height (meter)	Circumference 1 meter from base (cm.)	Sheaths stripped	Weight of Fibers Fresh (gram)	After 24 hrs. in shade (gm)	After 10 hrs. in sun (gm
1.....	1.70	29	15	140	102	97
2.....	1.65	27	13	113	91	85
Shade and Little Wind						
1.....	1.68	29	10	107	85	74
2.....	1.48	25	9	80	64	58

Plant No. 1 grown under sun and wind yielded 97 grams of sun-dry fiber. Plant No. 1 grown under shade with little wind yielded only 74 grams; or a difference of 23 grams in favor of the former.

Four samples of abacá fiber dried in the shade for twenty-four hours lost an average of about 8.1% moisture when further exposed to sun and wind for ten hours. Fiber dried for twenty-four hours in shade, even if very thoroughly spread and aired, still contains enough moisture to cause deterioration when stored for a long time.

Mature and Over-Mature Plants

About October, 1909, students in Agronomy II planted abacá in a deep valley where it is protected from the wind and shaded only by high trees. Another lot of the same variety was planted on the same date on a slope where it is exposed to sun and wind. The shaded plants were kept clean during recent years. On the other hand, the lot in the sun was given no care; shrubs and grass grew around the plants, and dead leaves were not removed, thus favoring the attacks of white ants. The rate of rotting of the leaf sheath was accelerated, and the normal growth and development of the plants was much hindered.

Since last year, some plants from both lots have been bearing flowers and fruit. Observations and measurements show that mature plants grown under shade and kept clean are larger than plants of corresponding age exposed to sun and wind but neglected. Two of the largest plants about to flower and two of the largest fruiting plants from each lot were stripped. The following results were obtained:

TABLE VI

Mature Plants

	In shade				In sun			
	I		II		I		II	
	Weight in gms.	*Length cms.*	*Weight in gms.*	*Length cms.*	*Weight in gms.*	*Length cms.*	*Weight in gms.*	*Length cms.*
1	11.75	150	10.25	159	3.04	106	2.40	88
2	21.85	154	20.68	188	4.88	106	7.15	122
3	20.62	161	23.79	205	8.20	175	9.00	163
4	30.77	207	24.93	226	9.15	193	10.64	181
5	30.47	194	25.93	239	12.34	195	13.83	186
6	32.05	242	32.12	241	10.89	200	15.83	200
7	30.47	220	26.80	263	19.81	208	15.34	200
8	35.75	267	31.62	265	20.67	222	15.66	208
9	22.14	255	31.38	273	19.48	225	11.05	210
10	23.45	295	30.92	270	13.46	223	10.22	200
11	42.59	294	25.54	273	10.85	214	9.69	205
12	22.65	289	29.91	273	11.17	222	9.50	208
13	35.90	293	27.85	273	7.47	220	8.94	208
14	34.05	298	21.20	269	8.73	216	8.64	217
15	28.25	296	26.99	271	9.66	226	10.13	217
16	23.81	298	16.72	268	12.30	218	10.37	213
17	9.59	287	10.34	255	13.35	223	11.25	213
18	17.13	285	3.83	250	10.23	215	6.45	188
19	12.40	279			6.05	188		
20	5.07	250						
Total	490.53		420.80		206.73		186.14	

TABLE VII

OVER-MATURE (*Fruiting*)

	IN SHADE				IN SUN			
	I		II		I		II	
	Weight in gms.	*Length cms.*	*Weight in gms.*	*Length cms.*	*Weight in gms.*	*Length cms.*	*Weight in gms.*	*Length cms.*
1	15.80	206	2.52	130	8.72	100	7.69	138
2	15.92	164	17.44	230	5.65	133	5.52	161
3	20.22	232	20.80	235	6.66	129	7.55	155
4	19.25	219	32.30	248	6.65	151	8.24	200
5	12.60	222	33.08	263	6.87	160	8.48	172
6	20.93	258	32.22	282	6.88	165	9.16	196
7	11.55	239	27.17	279	7.75	190	13.62	182
8	17.44	275	22.45	298	9.25	178	13.00	197
9	15.10	254	26.42	292	7.15	186	10.06	190
10	13.32	263	13.35	299	5.45	188	2.55	193
11	18.55	276	22.51	302	3.34	171	2.05	166
12	11.60	282	17.49	302	2.39	175	2.57	186
13	16.32	288	17.38	307	1.78	182	1.40	166
14	2.85	184	14.80	276	.85	125	1.00	115
15	4.05	245	15.82	292	.50	118		
16	3.90	230	13.03	296				
17	1.55	182	10.77	280				
18	4.50	277	6.89	248				
TOTAL	225.41		346.54		79.89		92.89	

TABLE VIII

SUMMARY OF PRECEEDING TABLES

	IN SHADE			IN SUN		
	Weight gms.	*Height to petiole*	*Cir. at 1 meter from base*	*Weight gms.*	*Height to petiole*	*Cir. at 1 meter from base*
Mature I	490.53	298	48	206.73	226	35
II	420.80	273	43	186.14	220	32
Average	455.27	285	45.5	196.43	223	33.5
Over-Mature (Fruiting) I	346.54	330	38	92.89	200	24
II	225.41	320	30	79.89	200	22
Average	285.975	325	34	86.39	200	23

The preceding tables show that the largest plants, about to flower, shaded but given care, produced an average of 455.27 grams of fiber, while two plants approximately of the same age, grown in the sun and wind, but neglected, yielded an average of only 196.43 grams; the difference is 258.84 grams, in favor of the plants shaded but cared for.

The largest fruiting trunks, grown under shade and cared for, yielded an average of 285.97 grams of fiber, whereas two largest stalks of similar age, grown in the sun but neglected, gave an average of only 86.39 grams or a difference of 199.58 grams in favor of the plants under the shade but cared for.

It is clear therefore that cleanness has a great deal of influence on the production of fiber, for one of the previous investigations performed by the author yielded results most convincing that abacá plants grown exposed to sun and wind yield more fiber, by weight, than plants grown under shade and protected from wind.

The tables also show that plants about to flower yield an average of approximately one hundred percent more fiber than plants with the fruit already half ripe.

Standard Grades of Abaca Strips

Under Act No. 2380 (Fiber Inspection and Grading Act), four grades of abacá strips are recognized: (1) Coarse brown; (2) Coarse; (3) Medium; (4) Fair. The determination of these grades is based on the width of strips more than on the color. Microscopical study of standard strips, furnished by the Bureau of Agriculture, was made and the average strength of each was tested. The test was based, not on the number of strips, but upon a unit weight of a gram; the length of the strip used was 60 centimeters.

Coarse brown.—"This is the lowest of the grades of abacá strips. The width of the strips in this grade is usually about one and one-half to two millimeters. The strips are thick and are, also, rough on the lower side owing to the presence of pulp. The color is usually that of seconds or brown."[1] Each strip is composed of from about 10 to 14 or 15 strands held together by dried epidermal and parenchymatous cells. These strips are obtained, in general, from the outermost leaf sheath, where the epidermis is colored. It was found that 0.58022 gram of material 60 centimeters long broke with a pull of 11.311 kilos; reducing this to a gram basis, it would require 19.494 kilos to break it. This is the weakest of all the strips, per unit of weight. This is due probably to the fact that the presence of parenchymatous cells adds weight to the sample without contributing to the strength.

Coarse.—"In width and thickness the strips in this grade are similar to those in the preceding grade. The color is higher and is similar to that of current or even midway." "It is very doubtful whether this and the preceding grade can be used to advantage for cordage purposes, excepting perhaps as a mixture with the higher grades."[2] The color is due to the presence of epidermis on some of its strips, especially at the tip, and probably it is affected also, to some extent, by the presence of some pulp; these strips may also come from the outside of the trunk.

Under the microscope, it was found that the strips usually contain 7 to 9 sclerenchyma strands, with some pieces of bundle sheath which are held together by parenchymatous cells. In strength this grade is next to the weakest. A sample of 0.43958 gram, 60 centimeters long, broke with a weight of 11.517 kilos; reducing this to a gram basis, it gave way under 26.2 kilos.

Medium.—"This is the third of the standard grades of abacá strips. The average width of the strips in this grade is about 1 millimeter, and the strips are, as a rule, smoother on the lower side and practically free from pulp. The color is either that of seconds or brown, or similar to that of coarse brown."[3] This color is due to the presence of a large amount of epidermal cells, which are colored—from the outside leaf sheath. On microscopical examination, it was found that the usual number of sclerenchyma strands is 4 to 6, held together by few parenchymatous cells with some epidermal cells. In strength, it stands third to the weakest or second to the strongest among the four grades of strips. It took 11.411 kilos to break a sample weighing 0.32968 gram, 60 centimeters long. Reduced to a gram basis, 34.612 kilos are required to break it.

1 *The Philippine Agricultural Review*, 7 (1914), Nos. 10, 11, and 12, p. 408.

2 *Ibid.*, p. 409.
3 *Ibid.*, p. 409.

Fair.—"The average width of the strips in this grade is about three-fourths of a millimeter to a millimeter, and the strips are usually thinner and contain less pulp than in any of the previous grades of this class of fiber. The color is ordinarily that of Current." [1] The strips that belong to this grade appear to be from leaf sheaths whose epidermis is not colored, which, therefore, were overlapped by one or more other leaf sheaths. Of the strips belonging to this grade, each usually contains one or two sclerenchyma strands with a few parenchymatous cells. Epidermal cells in this grade are few and, in most cases, found only at the tip of the strip.

A sample, weighing 0.3704 gram, 60 centimeters long (of seven average fibers) stood a strain of 13.972 kilos before it broke. Reducing this to a gram basis, it would require 37.721 kilos to break it.

TABLE IX

SUMMARY OF THE STRENGTH OF ABACA STRIPS

Standard Grades of Strip.	*Weight of sample*	*Breaking weight.*	*Strength calculated to a gram basis.*
	Gram.	Kilos.	Kilos.
Coarse Brown.....	0.58022	11.311	19.494
Coarse.....	0.43958	11.517	26.200
Medium.....	0.32968	11.411	34.612
Fair.....	0.37040	13.972	37.721

THE STANDARD GRADES OF ABACA FIBER

Samples of the standard grades of fiber, according to the Fiber Classification Law, were secured from the Bureau of Agriculture. The tensile strength of each grade, represented by six average-sized fibers, 60 centimeters long, was tested and the strength was calculated to a gram basis. The external description of the different standard grades of fiber is very brief in this paper. Full and complete descriptions of each grade are published in Volume VII (1914), Nos. 10, 11, and 12 of the *Philippine Agricultural Review*.

Prime and extra prime.—"These grades constitute the second and first, respectively, of the third or superior group. They are described together because their characteristics are very much the same in every respect, with the exception of color, which, although practically white in both grades, is more so in the extra prime than in the prime." [1] The supply of these grades comes chiefly from the Davao district, and the provinces of Cavite and Batangas.

The average tensile strength obtained from two trials of the extra prime is as follows: Sample weighing 0.10014 gram broke under a load of 6.015 kilos; the strength calculated to a gram basis is 60.065 kilos. The average stretching was 13.5 millimeters.

The average tensile strength from two trials of the fibers belonging to the grade prime was as follows: Sample weighing 0.13524 gram broke under a load of 8.265 kilos; the strength calculated to a gram basis is 61.113 kilos. The average stretching was 13 millimeters.

Superior current.—"This grade is the lowest of the third or superior group of grades. Its predominant color is light ivory yellow, a considerable portion of which usually approaches white." [2] The average of two trials of the strength of the fiber belonging to this grade is as follows: Sample weighing 0.14037 gram broke under a load of 8.367 kilos; the strength calculated to a gram basis is 59.606 kilos. The stretching was 13.7 millimeters.

Good current.—"This is the highest grade of the second group, and its predominant color is a very light ochre

1 *Ibid.*, p. 409

1 *The Philippine Agricultural Review*, 7 (1915), Nos. 10, 11, and 12, p. 407.

2 *Ibid.*, p. 407.

interspersed with small quantities of fiber of an ivory yellow or white color." [1] In the two trials made, the average weight of the sample was 0.1503 gram and it required a load of 9.167 kilos to break it. The strength calculated to a gram basis was 60.909 kilos. The stretching was 11.3 millimeters.

Midway.—"As the name implies, this grade is the medium grade of the second group, and represents in color a halfway transition from the current to the good current. The predominant color of this grade may be described as light ochre, and is often interspersed with small quantities of fiber of an ivory yellow color, which really belongs to a higher grade." [2] In the two trials made, the average weight of the sample was 0.2254 gram and it required a load of 11.614 kilos to break it. The strength calculated to a gram basis was 51.526 kilos. The stretching was 11.3 millimeters.

Current.—"This grade is unquestionably the most important of all the grades of abacá. Its importance does not consist in any superior quality of its fiber but in the extent of its supply and in the demand for it for cordage purposes." [3] The characteristic color of this grade is a very light brown. The average weight of two samples was 0.2407 gram, and it required a load of 11.009 kilos to break the set; the strength calculated to a gram basis is 45.737. The stretching was 12.5 millimeters.

Seconds.—The color of the fiber of this grade is usually light brown or light red mixed with yellow ochre. "As a rule, this grade is prepared from fiber obtained from the sheaths next to those on the outer side of the abacá stalk." [4] A better grade of fiber may turn into this grade through exposure to dampness. The average weight of sample of two trials made was 0.2201 gram and it required a load of 9.772 kilos to break the set; the strength calculated to a gram basis is 44.277 kilos. The stretching was 10.7 millimeters.

Brown.—"This is the lowest grade of the standard for the well cleaned fiber." [1] The color is usually brown or dark red, stained with light purple. This is prepared from fiber obtained from the outside leaf sheaths; or there may be fibers which originally belonged to a higher grade, but became dark through carelessness. The average tensile strength obtained from two trials is as follows: Sample weighing 0.2328 gram broke under a load of 7.711 kilos; the strength calculated to a gram basis is 33.122 kilos. The average stretching was 11 millimeters.

TABLE X

TABULATION OF STRENGTH OF STANDARD GRADES

Grade	*Stretching (mm)*	*Breaking weight (kilos)*	*Weight of sample (gram)*	*Strength calculated to a gram basis (kilos)*
A	13.5	6.015	0.10014	60.065
B	13.	8.265	0.13524	61.113
C	13.7	8.367	0.14037	59.606
D	11.3	9.167	0.15030	60.909
E	11.3	11.614	0.22540	51.526
F	12.5	11.009	0.02407	45.737
G	10.7	9.772	0.22070	44.277
H	11.	7.711	0.23280	33.122

SUMMARY AND CONCLUSION

1. The erect stem of abacá contains no sclerenchyma strands near the epidermis, differing in this respect from many monocotyledonous stems. This is due to the fact that this stem is enclosed and supported by many overlapping eaf sheaths, strong enough to hold up the leaf laminae, flowers, and fruit in their proper places.

2. The width of the sheaths of a trunk increases from the outermost to one-third or one-half of the way to the

1 *Ibid.*, p. 406.
2 *Ibid.*, p. 406.
3 *Ibid.*, pp. 404, 405.
4 *Ibid.*, p. 404.

1 *Ibid.*, p. 403.

middle; thence inward the width decreases. The yield of fiber varies with the width of the sheath. The outer sheaths produce a coarse, and often discolored fiber, suitable for cordage. The fiber from the inner sheaths is finer and weaker, and better adapted to textile use. The strongest fiber is from the widest sheath. Fibers from the edges of a sheath are stronger per unit of weight than those from the middle part of the same sheath.

3. Most fiber strands are situated near the outer epidermis, followed on the inside by sclerenchyma strands with some conducting tissue. Large vascular bundles are in the internal portion of the sheath; the largest are in the "bridge." The "discarded" portion of the sheath has few and small fiber strands and vascular bundles.

Fiber composed of cells having thin walls and wide lumina is weaker than fiber whose cells have thicker walls and narrower lumina. Contrary, however, to the common belief, fiber composed of long cells is weaker than that composed of shorter ones.

4. Plants exposed to sun and wind yielded almost double the amount of fiber produced by those under shade and with little wind. The formation of fiber is greatly influenced by cleaning the plantation.

5. The amount of fiber produced by a plant increases until about the time of flowering, after which the amount of fiber decreases rapidly.

6. The tensile strength of the fiber strips belonging to the standard grades of the present Fiber Act varies with the grade; the best grade is the strongest, and the worst is the weakest.

7. Assuming that the grades of abacá recognized by present law can be judged by standard samples, the first five grades, A to E inclusive, are about equal in tensile strength. The three lower grades are much weaker.

Acknowledgments

The writer is under special obligation to Professor Copeland, under whom this thesis was undertaken, for his suggestions and criticisms during the progress of the work.

References

1. Matthews, J. M., *The Textile Fiber*. Second Edition (1908) 314 and 315.

2. Hanausek, T. F., etc., *The Microscopy of Technical Products*. First Edition (1907) 75-76.

3. *Encyclopedia Britannica*. 17 (1911) 580.

4. Saleeby, M. N., *The Philippine Agricultural Review*. 7 (1914) Nos. 10, 11, and 12. Pp. 402-411.

Illustrations

All figures, excepting Plate I and Plate V, Fig. 1, are magnified 108 diameters.

Plate I

Fig. 1. Cross-section of a fruiting "false trunk;" the center is the stem.

Fig. 2. Cross-section (diagrammatic) of the leaf sheath X, of Fig. 1.

Plate II

Figs. 1–5 inclusive. Cross-sections of fiber strands of the outermost leaf sheath one-half meter from the base of the trunk.

Figs. 6 and 7. Cross-sections of sclerenchyma strands with some conducting tissue, from the outermost sheath, one-half meter from the base.

Figs. 8 and 9. Cross-section of the second largest and largest vascular bundles from the internal portion of the outermost leaf sheath, one-half meter from the base.

PLATE III

Figs. 1–8 inclusive. Cross-sections of fiber strands from the outermost leaf sheath, one and one-half meters from the base of the trunk.

Figs. 9 and 10. Cross-sections of sclerenchyma strands with some conducting tissue from the outermost leaf sheath, one and one-half meters from the base.

Figs. 11 and 12. Cross-section of the second largest and largest vascular bundles from the internal portion of the outermost leaf sheath, one and one-half meters from the base.

Fig. 13. Cross-section of a fiber strand from the "discarded" portion of the outermost leaf sheath, one and one-half meters from the base.

Fig. 14. Cross-section of a sclerenchyma strand with phloem from the "discarded" portion of the outermost leaf sheath, one and one-half meters from the base.

Fig. 15. Cross-section of vascular bundle from the "discarded" portion of the outermost leaf sheath, one and one-half meters from the base.

PLATE IV

Figs. 1, 3, 5 and 6. Cross-sections of fiber strands from the outermost leaf sheath, at the base.

Figs. 7 and 8. Cross-section of sclerenchyma strands with some conducting tissue from the outermost leaf sheath, at the base.

Figs. 9 and 10. Cross-section of vascular bundles from the portion shown by the letter K in Plate I, Fig. 2.

Fig. 11. Cross-section of the largest vascular bundle in a leaf sheath from the "bridge" at the base.

PLATE V

Fig. 1. Portion of the cross-section of a leaf sheath about one inch from the edge, showing the distribution of fiber strands and vascular bundles. (Diagram.)

Figs. 2 and 3. Cross-section of fiber strands from A and B of Fig.1.

Fig. 4. Cross section of the largest vascular bundle from the internal portion of the leaf sheath, one inch from the edge. (See Fig. 1-C.)

Fig. 5. Cross-section of a fiber strand, from market fiber.

Fig. 6. Cross-section of a sclerenchyma strand with some conducting tissue, from market fiber.

Fig. 7. Cross-section of a fragment of sclerenchyma strand.

Fig. 8. Portions of fiber cells from near the epidermis one inch from the edge of the leaf sheath.

Fig. 9. Portions of fiber cells from the edge of the leaf sheath.

Fig. 10. Portions of fiber cells from the waste portion.

Fig. 11. Portions of fiber cells from about the second row of sclerenchyma strand from the epidermis, the middle part of the sheath.

Fig. 12. Portion of fiber cells from near the outer epidermis at the midrib.

Fig. 13. Portion of fiber cells from the internal portion of the leaf sheath which, in stripping, is thrown away as waste.

A Study of the Effects of Commercial Fertilizers on Corn

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Numerous experiments on the fertilizing of corn have been performed in the United States and elsewhere. In the Philippines, up to the present time, the use of commercial fertilizers is practically unknown among the farmers. So, experiments of this kind are of very great importance.

It is true that by chemical analysis, we are able to know what forms of plant food, and their approximate amounts, are present in a soil; but, since the factors which influence the availability of these respective plant foods are so numerous, this analyzing of the soil will not be a sufficient guide for the application of fertilizers, especially if commercial fertilizers are used.

Philippine soils, as a whole, are commonly considered almost inexhaustible as to plant food, and fertilization of any kind is said not to be needed. This is possibly true to some extent because of the relative virginity of the soil, although there are parts that are becoming exhausted. But a soil, however rich, will, if it is continuously cropped without following any system of effective conservation, be reduced to a sterile wilderness. It is absurd to await this outcome before supplying the necessary plant food. We must study to prevent the irrational losses and maintain or even increase the fertility, and not wait until the soil is "dead."

The fertility of the soil in general largely determines the size of any crop. Soils containing all the essential elements may yet produce a poor crop, if any one food needed by this crop is not present in sufficient amount; for no element can take the place of another as nourishment for a growing plant. Most soils lack three or four of the essential plant foods, nitrogen, phosphorus, potassium and calcium.

The chemical composition of a soil is not the only governing factor in crop yield. It is dependent also on physical conditions. The elements of plant food are useful to the plant, only when they can be absorbed by the roots. If the soil is too compact or is clogged with water because improperly tilled or drained; or, is too loose or too dry through need of green manuring, liming and irrigation; or, if it is too acid when liming will correct it; then, no matter how rich chemical analysis may show it to be, such soil can not produce ordinary crops of any considerable value.

In the Philippines, there are places where the dry season is very marked, while in other localities there is hardly any drought. The time for planting corn must be fixed in localities according to the seasonal rainfall; for its modification through irrigation is not within the limit of control in many regions at the present time.

Water supply is one of the most important factors which controls the growth of corn and therefore its yield. Too much rain during the period when the corn is young and tender may hinder the growth or even kill the plant. Too heavy a rain during the most active stage of pollination may result in a considerable lessening of the yield. And rain during the proper time for harvesting may cause rotting and thus reduce the value of the product. Other things being favorable, the least amount of water necessary in the soil will be the amount absorbed, plus, of course, the hydroscopic soil moisture. Since the amount of food materials can only enter

the plant in solution in water, the growth may be in proportion to the amount of water absorbed.

There is little danger of its having too much light or too intense sunshine, provided the roots are properly supplied with moisture; for corn is a sun-loving plant. Like other plants, corn is influenced by the movement of the air. Wind increases the transpiration. Because of this the roots absorb more water and as a consequence more food elements are taken up by the plant. This in turn results in vigorous growth and increased yield.

The kind of seed planted and its suitability to the local physical conditions are important factors in corn production. Goodness of seed involves high vitality, perfect acclimatization, i. e., to soil and climate, hardness and resistance to adverse conditions, and, especially, high productiveness. Seed which produces a good crop in one locality may not be suited to another place. Each locality by tests must determine the kind of seed best adapted to its peculiar conditions.

However good the seed and the climatic and soil conditions, diseases or pests of some kind or other always occur in the corn field. Starting from the time of seed planting, both the ants and the termites may eat the germs of the kernels, as happened in some of the writer's culture plots. When the seeds have sprouted, started growth, and become promising, fungus, as for instance, *Sclerospora*, may appear, causing first the production of yellow stripes on one or more leaves and then gradually but rapidly spreading over all of them, checking the growth of the plants and in most cases killing them. Again, locusts may come and eat all the parts of the young plant to the ground, or when older the blades alone, leaving only the stalks and midribs. Even when the ears have appeared and the kernels formed, the larvae of certain insects may burrow into the ears and destroy them.

The experiment stations of the United States have solved a great many problems concerning fertilizers for corn production. At the Kentucky Experiment Station, the experiments in 1888 showed that wherever sulphate of potash was applied, there was always an increase in yield of both ear corn and fodder. The plots receiving acid phosphate and ammonium sulphate produced no increase. According to the financial results, potash always gave a net profit wherever it was applied; and the plot where it was applied alone in the hill at the rate of 60 lb. per acre yielded the largest gain. None of the cost of the fertilizers was recovered from the plot where no potash was used, and so there was a loss of at least their cost. The greatest yield and profit were obtained from the use of potash and nitrogen in the form of muriate and a nitrate. The after-effect of potash was said to be shown, not only in the first and second years, but also in the third, and to a certain extent, even in the fourth (VI). The experiments conducted in different places in Massachusetts resulted in the recommendation that potash be not omitted wherever fertilizer is to be used for corn in the soil of that state.

In an experiment at the Georgia Station (VII), a yield of 75 bushels of corn per acre was secured where a complete fertilizer of 29.7 lb. of available nitrogen, 69 lb. of available phosphoric acid, and 42 lb. of available potash, equivalent to an application of 700 lb. of a 4-10-6 fertilizer formula, was applied. The yield obtained the previous year from similar land receiving no treatment was only about 11 bushels of corn per acre. From this, it was concluded that it will pay the average man to use high grade

fertilizers in large amounts on corn, provided the land is deeply broken, thoroughly prepared, and well tilled.

From a three-year nitrogen test at the same station, using cotton-seed meal, nitrate of soda, and sulphate of ammonia, the following was secured: (Note: All are averages for three years.)

Cotton-seed meal	28.94 bushels shelled corn per acre
Nitrate of soda	31.57 bushels shelled corn per acre
Sulphate of ammonia	31.92 bushels shelled corn per acre
Not fertilized	25.38 bushels shelled corn per acre

Out of 37 experiments in various parts of Texas, 31 produced increases of ear of corn in favor of the acid phosphate, 17 in favor of the cotton-seed meal, and only 12 in favor of the potash.

In many parts of Europe and in other regions, it has been found, as the result of experience, that the increased yield of agricultural products has been principally due to the liberal use of fertilizers. In Germany, 50% of the increase is said to be due to the rational use of fertilizers (IX). In different parts of Hungary, the use of fertilizers containing phosphoric acid and potash results in highly remunerative yields (IX).

On the South Coast, New South Wales, Australia, the following complete fertilizers gave the best green fodder (X):

Dry blood	3 cwt.
Bone dust	2 cwt.
Superphosphate	4 cwt.
Sulphate of potash	1 cwt.

This is equivalent to:

4½%	Nitrogen.
10 %	Phosphoric acid.
5½%	Potash.

and was applied at the rate of 1½ cwt. per acre.

Fertilizer experiments on corn in the Philippines are yet too few to be used to ascertain the needs of the common types of soil for corn production. The experiments of Mr. Vicente W. Pastor in Cebu have already been cited by Mr. T. N. Vibar in 1911 so that no very detailed survey of them need be made here (I.) The table of the results of Mr. Pastor's plot experiments shows that nitrogen played a very important part in increasing the yield. Wherever it was applied, whether in the form of manure, ammonium sulphate or saltpeter, it always made apparent increases either alone or in combination. On the other hand, potassium carbonate, calcium superphosphate, and guano all decreased the yield, except when they were in combination.

As a result of Mr. Vibar's fertilizer experiment, the application of tankage, basic slag and kainit combined, was recommended. This combination and, to a less extent, tankage applied alone, yielded profits. From this it can safely be said then, that the soil under consideration needs phosphorous and nitrogen, and only very little potash, if it needs it at all.

As to growth, it was said that, "The height of the plant increased gradually with the time; a sudden jump took place in the seventh week after planting; the growth was in its maximum in the eighth week, decreasing suddenly in the tenth and stopping in the eleventh (I).

It was the aim of the present study to make a planting before or at the beginning of the college year, but because of the existing fungus in the field, the heavy rains which favor the rapid development of this disease, and other unfavorable seasonal conditions, successful cultures were not secured until almost the middle of the college year.

OBJECTS

The objects in view in this fertilizer work are:

1st—To ascertain whether it will pay, at present, to apply a reasonable amount of commercial fertilizers to

corn on the college farm, the soil of which represents a common type in the Philippines; or, whether other means of enriching the soil are more likely to obtain the maximum yield with the least cost of production.

2nd—To ascertain which of the three most important plant food elements in commercial fertilizers, i. e., nitrogen, phosphorus, and potassium, is, or are needed by this soil, if it needs them at all.

3rd—To ascertain whether corn prefers one form of fertilizer rather than another that supplies the same element of plant food.

4th—To ascertain whether it pays to apply larger amounts of nitrogenous fertilizers on corn than a crop of 70 bushel ear corn and 6000 lb. stover per acre will remove from the soil.

5th—To determine the effects on corn of various amounts of lime.

6th—To determine the effects of the fertilizers on the growth of corn.

FIRST CULTURE

Great care was employed in the selection of the ground. The history of the field, i. e., the previous treatment it received, revealed the fact that no fertilizer of any kind had ever been applied to it. It had, however, been planted with sugar cane, corn, camoting cahoy (*Manihot utilissima*), soy bean, and sweet potato and corn. The soy bean crop was said to be a poor one, so that not much fixed nitrogen was obtained for the subsequent crops. Before these treatments, beginning from the year 1910 back, no reliable record could be secured. It must have been, however, under sugar cane and corn alternately, for these are the principal crops planted in the vicinity at present, and were so previous to the establishment of the college.

The soil is a fine compact loam, inclined to be clayey. Its depth varies from about forty centimeters to more than half a meter. The subsoil is adobe rock.

The first plowing, followed by harrowing, was done August 10th, 1914. The second was on the 19th of the same month. Heavy rains after this preparation slightly packed the soil, making it necessary to go over it with the two-toothed cultivator before harrowing it with the smoothing harrow on September 18th.

The furrowing was done September 19th. The distance between the furrows was seventy-five centimeters, and one and a half meters between plots. There were three furrows to a plot; hence the area of each plot was 138 square meters or 0.0138 hectare.

The fertilizers used were:

Sulphate of ammonia	20%
Nitrate of soda	15%
Double superphosphate	40%
Single superphosphate	20%
Sulphate of potash	40–48%
Muriate of potash	40–49%

The amount of fertilizers applied per plot was calculated, first on the assumption that a crop, of 70 bushels ear corn and 6,000 pounds stover, remove from the soil 100 pounds nitrogen, 50 pounds phosphoric acid, and 60 pounds potash per acre; and that the soil in order to produce the same or a larger crop, must be resupplied with at least the same amounts of the same ingredients. The amounts used in the mixture of two or three fertilizers, supplying the different essential elements, were calculated on the basis of the 2-7-6 (N. P. K.) formula.

The application of pertilizers to the several plots, with calculated application to hectares, and of the elements, is shown by the following table:

AMOUNT OF FERTILIZERS USED, IN KILOGRAMS
FIRST CULTURE

PLOT	NAME OF FERTILIZER	N. per Ha.	P. per Ha.	K. per Ha.	FERTILIZER per Ha. equivalent to: N.	P.	K.	TOTAL OF FERTILIZERS per. Ha.	per Plot
1.	Check							0	0
2.	Nitrate of Soda	11.4			760			760	10.49
3.	Double Superphosphate		57			142.5		142.5	1.97
4.	Sulphate of Potash			68			170	170	2.35
5.	Sulphate of Ammonia	11.4			570			570	7.87
6.	Single Superphosphate		57			285		285	3.94
7.	Muriate of Potash			68			170	170	2.35
8.	Lime							1000	13.8
9.	Check							0	0
10.	Sulphate of Ammonia + Double Superphosphate	45.5	159		227.5	397.5		625	8.62
11.	Nitrate of Soda + Single Superphosphate	45.5	159		303.4	795		1098.4	15.17
12.	Sulphate of Ammonia + Sulphate of Potash	45.5		136.3	227.5		340.8	568.3	7.94
13.	Nitrate of Soda + Muriate of Potash	45.5		136.3	303.4		340.8	644.2	8.99
14.	Lime							2000	27.6
15.	Single Superphosphate + Muriate of Potash		159	136.3		795	340.8	1135.8	15.78
16.	Double Superphosphate + Sulphate of Potash		159	136.3		397.5	340.8	738.3	10.28
17.	Nitrate of Soda + Double Super. + Sul. of Potash	45.5	159	136.3	303.4	397.5	340.8	1051.7	14.47
18.	Sul of Ammonia, + Sgle. Super., + Muriate of Potash	45.5	159	136.3	227.5	795.8	340.8	1363.3	18.92
19.	Check							0	0

All the corresponding potash (sulphate and muriate) and phosphoric acid fertilizers (double and single superphosphates), and lime, were applied September 19th. They were applied in the furrows by hand and then covered with the soil. Care was employed in distributing them evenly.

The nitrogen fertilizers were not applied until some time after planting. This was done to avoid losses by leaching and in other ways. One-half of the calculated amount to be applied to the corresponding plot was applied October 8th, nineteen days from the time of planting. The remaining half was applied October 22nd, thirty-one days after planting.

The entire field was planted just after the application of the potash and phosphoric acid fertilizers on September 19th. The planting was done by dropping three kernels of corn every seventy-five centimeters in the furrows, and covering them to a depth of two or three centimeters. On replanting, September 29th, two kernels were planted in the hills where only one had sprouted and three where none grew at all.

The seed used, obtained from one of the neighboring farmers, was a good grade of the common yellow native flint. Forty ears of this were found to weigh 8.87 kilograms. All were shelled, excluding the butts and tips, and thoroughly mixed to insure seed as uniform as possible. Only twenty-five of the ears were used.

The growth of weeds was prevented as far as possible, to insure a full supply of the applied fertilizers to the corn plants. Frequent and shallow cultivation was therefore necessary, not only to get rid of the weeds, but also to have a soil of good physical condition, a very important factor in connection with the availability of the plant food.

The entire field was cultivated five times during the season, on September 30th, October 14th, 19th, and 31st, and November 19th. This number of cultivations was sufficient to keep the whole field almost free from weeds of any kind, and in a perfect state of tilth.

The majority of the hills in plots 1, 2, 3, 5, 9, 10, and 19 germinated September 23rd, four days after planting; those of plots 4, 6, 7, 8, 11, and 12, September

24th; those of plots 14, 16, 17, and 18, September 25th; and those of plots 13 and 15, September 26th.

A record as to the percentage of germination (stand) was made a week after the replanting, and it was found to be as follows: plots No. 1, 98.9%; No. 2, 96.7%; No. 3, 97.3%; No. 4, 96.2%; No. 5, 97.3%; No. 6, 97.3%; No. 7, 91.4%; No. 8, 98.4%; No. 9, 97.3%; No. 10, 98.4%; No. 11, 98.4%; No. 12, 95.7%; No. 13, 96.7%; No. 14, 97.3%; No. 15, 93.5%; No. 16, 96.7%; No. 17, 97.8%; No. 18, 97.3%; No. 19, 94.6%.

Beginning twelve days after planting, weekly measurements were made to determine the growth of ten plants in each plot. The following table is a compilation in which each number is the average of the ten determinations made on the plot in question.

AVERAGE WEEKLY GROWTH OF EACH PLOT

IN MILLIMETERS

NUMBER OF PLOTS	WEEKS										
	1st*	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	*Average Height*
1	280.8	243.7	318.5	382.8	412.3	390.6	628.8	168.7	3.2	0	2423.7
2	247.7	240.8	324.2	459.8	490.5	395.3	592.0	82.1	1.5	0	2387.0
3	241.1	229.1	265.8	366.7	370.9	405.0	590.0	43.3	1.0	0	2204.5
4	250.9	247.8	316.2	334.6	402.0	379.6	716.6	96.2	5.0	0	2349.0
5	258.2	200.4	290.0	346.5	398.9	381.0	715.6	118.4	7.5	0	2317.0
6	266.7	187.3	279.3	334.6	342.1	342.5	623.3	51.0	3.0	0	2062.5
7	190.5	166.6	251.9	375.2	209.8	307.0	504.5	348.0	4.0	0	2071.5
8	261.5	206.7	292.3	345.5	319.4	235.8	621.2	190.0	1.2	0	2182.2
9	231.7	247.2	230.1	311.5	300.9	250.6	545.5	199.2	.3	0	2038.3
10	245.7	211.9	295.0	343.5	353.9	324.1	639.8	147.7	1.5	0	2113.5
11	257.2	216.7	286.6	340.5	361.5	330.0	628.0	116.5	4.0	0	2071.0
12	214.0	172.2	274.8	282.5	369.0	365.5	485.0	232.5	6.5	0	2161.5
13	119.5	145.7	254.0	260.3	299.0	331.3	302.9	359.9	109.5	0	1898.0
14	231.9	194.1	301.0	269.0	313.0	279.2	360.9	350.0	6.0	0	2023.0
15	228.2	202.6	309.6	345.7	370.9	356.0	582.3	156.3	10.0	0	2243.5
16	254.6	277.3	311.9	315.2	349.0	346.7	724.3	111.0	3.5	0	2259.5
17	261.7	218.3	358.5	357.0	376.5	356.7	715.0	101.0	3.0	0	2236.7
18	258.7	232.5	334.3	355.5	390.5	348.0	635.4	153.0	30.0	0	2200.5
19	238.3	271.8	348.2	295.2	295.0	340.1	501.6	283.8	8.5	0	2333.0

* This is really 12 days (1 week and 5 days) from the time of planting, or one week from the average date of first appearance above the ground.

Averaging the three check plots, 1, 9, and 19, we have the following final order of the rapidity of growth: plot No. 18, first; plot No. 4, second; plot No. 17, third; plot No. 2, fourth; plot No. 5, fifth; plot No. 16, sixth; etc. (See table).

From these statistics and from field observations, it is safe to say that by supplying the three most essential plant foods in the soil, either in the form of nitrate or ammonia for nitrogen, single or double superphosphate for phosphoric acid, muriate or sulphate of potash for potash, the growth of corn is accelerated. Nitrogen, in the form both of nitrate and ammonia, applied alone or in combination with phosphoric acid, and to a less extent with potash, caused a rapid increase in height of the corn and a

thickening and enlargement of both stalks and foliage. Potash in the form of sulphate applied alone, and muriate to a much less extent, caused a more rapid increase in height, but not so much enlargement of stalks or of the leaves. The effect of phosphoric acid on the growth was variable. According to the field observations, it seems to have caused an earlier maturity than either nitrogen or potash, and to have invigorated the plants, for the color and size closely approached that of the nitrogen plots. It did not cause a more rapid increase in height, but did strengthen the more important parts of the plant, the ears.

Harvesting was done December 28, 29, 30 and 31, exactly 100, 101, 102, and 103 days respectively after planting. The stalks were cut close to the ground, the ears separated, husked, classified and weighed.

The ears were divided into three classes: marketable, unmarketable, and culls. "Marketable" ears, as here understood, are those that are of good size and well formed (good for seed), with plump and good kernels, and worth one centavo each in the local market. "Unmarketable" ears are those that are partly damaged by insects or otherwise, or those that have not fully filled the cobs with kernels, or those having good kernels but small. They can be marketed at the rate of about five ears for one centavo. "Culls" are those ears that are almost useless. They contain kernels, but scattered and not well developed. They may be marketed at the rate of ten ears per centavo.

The yield of each plot and the calculated profit or loss are shown in the following tables:

THE YIELD OF EACH PLOT

PLOT NO.	EARS						STOVER ETC.		
	Marketable		*Unmarketable*		*Culls*		*Husks*	*Stalks and Leaves.*	
	No.	Wt.	No.	Wt.	No.	Wt.	Wt.	No.	Wt.
1	140	25.0	100	9.6	70	3.0	11.3	340	81.5
2	149	27.2	99	9.2	61	2.5	10.3	366	84.4
3	150	27.5	110	10.0	70	2.8	10.4	395	83.3
4	138	23.6	85	8.1	76	3.2	10.3	346	74.6
5	146	26.5	85	8.8	59	3.4	11.5	338	74.8
6	155	26.8	85	7.6	58	2.9	12.5	335	64.4
7	131	21.7	60	5.5	42	3.8	9.3	295	58.9
8	142	24.6	78	7.2	47	2.9	9.1	336	69.7
9	134	24.6	94	8.2	56	2.8	9.5	356	73.5
10	137	23.0	101	9.0	70	3.2	10.4	358	75.0
11	155	26.4	106	9.8	68	2.9	10.1	369	72.7
12	101	15.4	90	8.6	52	2.3	8.8	304	62.6
13	100	14.3	106	10.0	52	3.2	11.1	326	69.3
14	120	19.0	87	7.9	47	2.0	7.2	338	59.2
15	94	15.1	112	10.8	46	3.4	10.0	336	78.5
16	130	20.8	104	9.6	44	2.5	11.2	360	78.9
17	137	20.7	117	11.9	67	3.4	10.2	400	79.6
18	127	24.5	110	10.6	87	4.6	11.7	369	87.0
19	91	15.0	137	11.2	39	1.8	6.9	340	61.5

From these tables, it can be seen that the heaviest yield of marketable ears came from plots 6 (single superphosphate), and 11 (single superphosphate and nitrate of soda), amounting to 155 ears in each case. The next heaviest yields are from plots 3 (double superphosphate), 2 (nitrate of soda), and 5 (sulphate of ammonia), 150, 149, and 146 ears respectively.

From these results, it can be said that phosphoric acid, especially in the form of single superphosphate, gave the greatest increase in yield of marketable ears. Nitrogen caused some increase in yield where applied in much larger amounts than the phosphoric acid, but the observations on yield would lead to the conclusion that nitrogen was not badly needed by the soil. The records showed that potash did not increase the yield. In some plots, by apparently weakening the resistance to mildew, it decreased the yield of both ear corn and stover.

Lime, applied in amounts not greater than 1,000 kilogram per hectare, was found to increase the production enough to make its use likely to be profitable.

Basing conclusions as to the effect of the fertilizers on the total weight of all the ears, it was found that the largest yield was made by the phosphoric acid fertilizer, applied alone (Plot 3), and when in combination with nitrogen.

As to stover, the largest amount produced was found to be in plot 18, where sulphate of ammonia, single superphosphate and muriate of potash were applied. There was also a considerable increase made in plot 17, where nitrate of soda, double superphosphate and sulphate of potash were used. This shows the effect of supplying together the three elements: N, P and K to the soil. The order of effectiveness, taken singly, of the elements of plant food in the production of stover is: first, N; second, P; third, K; and fourth, Ca. In combination of two elements they are respectively: PK, NP, and NK.

Valuing the three classes of ears, at one marketable, or five unmarketable, or ten culls for one centavo, we have the following table:

THE VALUE OF THE YIELD, COST OF PRODUCTION, AND PROFIT OR LOSS PER PLOT

PLOT	VALUES OF EARS			Total Value	Cost of Production	or loss Profit
	Marketable	Unmarketable	Culls			
	₱	₱	₱	₱	₱	₱
Check *	1.22	.22	.05	1.49	.85	+ .64
2	1.49	.20	.06	1.75	2.54	— .79
3	1.50	.22	.07	1.79	1.21	+ .58
4	1.38	.17	.08	1.63	1.35	+ .28
5	1.46	.17	.06	1.69	2.39	— .70
6	1.55	.17	.06	1.78	1.19	+ .59
7	1.31	.12	.04	1.47	1.34	+ .13
8	1.42	.16	.05	1.63	1.16	+ .47
*						
10	1.37	.20	.07	1.64	2.35	— .71
11	1.55	.21	.07	1.83	2.24	— .41
12	1.01	.18	.05	1.24	2.45	—1.21
13	1.00	.21	.05	1.26	2.51	—1.25
14	1.20	.17	.05	1.42	1.47	— .05
15	.94	.22	.05	1.21	2.21	—1.00
16	1.30	.21	.04	1.55	2.37	— .85
17	1.37	.23	.07	1.67	3.15	—1.48
18	1.27	.22	.09	1.58	3.03	—1.45

* Average of plots 1, 9 and 19.

As to the profit resulting from the fertilizers used, basing the estimates on one crop only, phosphoric acid, lime, and potash, each applied separately, were the only ones that gave increase in yield to more than cover the cost. However, experiments elsewhere have demonstrated that these fertilizers are effective on subsequent crops: lime for perhaps five years; potash, four years; and phosphoric acid, three crops; nitrogen is easily leached and consequently is soon carried out of reach of the roots.

As the subsoil where this experiment was conducted is almost impenetrable by the soil water, the soluble plant food would be retained in the soil, so the profit would really be greater and the losses smaller than the table appears to show.

Second Culture

The second culture, the object of which was to check the first, was the same in all respects except in the use of the nitrogenous fertilizers.

The ground where this culture was conducted is very level. Until the previous season, when it was planted in corn, it had been uncropped for some years.

The field was plowed twice, followed each time by the disk and harrow. On September 25, about a week after the first plowing, the butts of the talahib (*Saccharum spontaneum*) were removed, as their growth might interfere with the effects of the fertilizers. The second plowing was on October 9 and 10. The field was furrowed in the same manner as in the previous culture.

The potash and phosphoric acid fertilizers of plots 3, 4, 6, 7 and 10 were applied October 20th; those of plots 8, 11, 12, 13, 17 and 18, October 23rd; and those of plots 14, 15, and 16, October 24th. All of the nitrogenous fertilizers for plots 10, 11, 12, 13, 17 and 18 and one-half of those for plots 2 and 5 were applied November 11th. The rest of those for plots 2 and 5 were applied December 10th.

The amounts of fertilizers used per plots are as follows:

Plot No.	*Name of Fertilizers.*	*Amount in Kg.*
1	None	0
2	Nitrate of soda	9.12
3	Double superphosphate	1.71
4	Sulphate of potash	2.04
5	Sulphate of ammonia	6.84
6	Single superphosphate	3.42
7	Nitrate of potash	2.04
8	Lime	12.00
9	None	0
10	Sulphate of ammonia	4.44
	Double superphosphate	4.77
11	Nitrate of soda	4.82
	Single superphosphate	9.54
12	Sulphate of ammonia	4.44
	Sulphate of potash	4.09
13	Nitrate of soda	4.82
	Muriate of potash	4.09
14	Lime	24.00
15	Single superphosphate	9.54
	Muriate of potash	4.09
16	Double superphosphate	4.77
	Sulphate of potash	4.09
17	Nitrate of soda	4.82
	Double superphosphate	4.77

AVERAGE WEEKLY GROWTH OF EACH PLOT

IN MILLIMETERS

NO. OF PLOTS	WEEKS										*Average Height.*
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	
1	263.1	152.7	242.4	355.2	341.6	401.5	735.4	159.7	4.8	0	2241
2	255.0	128.1	248.6	360.1	392.7	557.0	897.7	155.3	6.0	0	2406
3	248.0	160.5	264.0	346.5	390.2	569.3	767.0	94.5	5.5	0	2396
4	246.5	159.4	232.1	392.2	381.8	572.0	813.9	233.5	14.5	0	2503
5	234.1	181.7	286.4	399.3	377.0	529.5	773.0	141.0	2.0	0	2420
6	268.6	204.1	293.0	388.2	460.1	622.5	629.5	111.5	4.5	0	2568
7	246.2	188.8	296.9	346.5	415.6	588.2	616.5	114.0	12.0	0	2372
8	269.0	175.8	274.2	342.0	463.0	515.0	728.5	28.5	5.0	0	2377
9	259.3	199.4	296.3	347.5	395.0	409.5	620.5	59.8	13.5	0	2233
10	270.0	196.7	292.8	415.9	475.6	480.5	587.0	107.0	7.0	0	2478
11	236.3	199.5	264.9	311.6	430.2	600.0	705.5	59.5	4.0	0	2451
12	254.6	140.2	290.7	350.5	351.5	388.5	659.5	141.5	13.0	0	2219
13	227.0	154.0	241.0	280.5	370.8	431.5	592.3	68.0	10.5	0	2307
14	236.3	154.3	286.4	401.0	388.5	530.0	559.8	132.5	1.5	0	2335
15	237.4	151.0	247.1	318.5	385.0	530.0	745.5	112.0	28.0	0	2262
16	250.8	150.6	248.1	375.7	421.9	566.1	683.3	96.0	10.5	0	2334
17	263.5	158.7	258.0	385.5	398.8	518.2	520.0	228.5	12.5	0	2401
18	249.5	177.9	315.6	463.5	464.5	511.0	528.0	43.0	3.5	0	2454
19	261.1	150.3	283.1	391.9	436.1	591.7	591.5	139.5	9.5	0	2438

	Muriate of potash	4.09
18	Sulphate of ammonia	4.44
	Single superphosphate	9.54
	Muriate of potash	4.09
19	None	0

The planting was done Oct. 24th. The method and distance were the same as in the first culture. These plots were cultivated only four times during the season, on Nov. 2nd, 10th, and 25th, and Dec. 5th.

The germination was recorded three to five days after planting. The percentages of stand two weeks after replanting were as follows: plots 1, 98.1%; 2, 97.5%; 3, 97.5%; 4, 95.6%; 5, 96.2%; 6, 97.0%; 7, 96.2%; 8, 96.9%; 9, 94.3%; 10, 98.1%; 11, 98.7%; 12, 98.7%; 13, 98.1%; 14, 98.1%; 15, 97.5%; 16, 98.7%; 17, 96.9%; 18, 98.7%; 19, 98.1%.

As before, weekly measurements were made to find the height of ten plants in each plot. The following tables show the average growth on each plot and average total height and the calculated profit or loss.

It will be seen from this table that the effects of fertilizers on the growth were similar to the results obtained in the first culture. Comparing the order of the effectiveness of the elements on the growth of corn of the first and second cultures, we have:

Rank	*1st Culture*	*2nd Culture*
1	NPK	K
2	N	NPK
3	PK	P
4	Check	N
5	K	NP
6	NP	Check
7	NK	Ca'
8	P	PK
9	Ca'	Ca'
10	Ca'	NK

This culture was harvested January 25, 26, 27, and 28, respectively 93, 94, 95 and 96 days after planting. The cutting, separation of the ears from the stalks, husking, classifying and weighing of the ears and stover, were all accomplished on the days mentioned.

The following table shows the yield of each plot as to the three classes of ears: marketable, unmarketable and culls, and the weights of the stover

THE YIELD OF EACH PLOT

SECOND CULTURE

Plot No.	*EARS*						*STOVER etc.*		
	Marketable		*Unmarketable*		*Culls*		*Husks*	*Stalks and leaves*	
	No.	*Wt. Kg.*	*No.*	*Wt. Kg.*	*No.*	*Wt. Kg.*	*Wt. Kg.*	*No.*	*Wt. Kg.*
1	138	25.8	85	7.7	39	2.2	11.2	310	68.0
2	149	26.8	66	5.2	39	1.8	13.6	308	66.5
3	161	26.4	68	6.5	33	1.2	10.3	323	69.5
4	148	26.4	80	7.3	23	.7	9.8	309	70.2
5	139	24.0	70	7.2	27	1.5	10.8	304	65.5
6	146	28.0	91	9.1	26	1.2	10.5	321	74.8
7	116	21.6	80	8.1	38	1.4	11.9	318	81.6
8	133	23.8	75	6.5	30	1.2	10.9	315	75.3
9	120	23.8	80	8.4	39	1.9	11.0	318	80.4
10	152	31.3	80	8.6	46	2.5	11.8	347	89.0
11	164	29.0	85	7.8	25	1.1	11.2	316	79.9
12	157	30.4	93	9.6	36	2.1	10.1	365	80.5
13	114	23.1	81	8.4	36	2.2	11.1	314	85.2
14	159	31.7	85	8.4	28	2.7	10.8	362	81.6
15	155	28.2	71	6.1	45	2.0	14.0	333	90.5
16	177	33.1	68	6.3	26	1.1	12.0	331	82.4
17	160	30.2	86	8.1	18	.7	10.4	283	71.9
18	163	31.7	78	7.8	27	1.6	11.2	321	82.7
19	154	28.7	68	6.6	25	1.5	14.1	346	74.9

The importance of phosphoric acid for this soil is again shown. Apparent increases were always obtained by its use. Its greatest effect was in combination with potassium, with NK second, and with N third. Even when applied alone, the increase made was very remarkable, especially in the number of marketable ears.

The effects of the fertilizers can be better studied and understood with the aid of the following table:

THE EFFECTS BY ELEMENTS

Elements in fert. used	*Average of plots*	*No. of Marketable ears*	*Total Wt. of all ears Kg.*	*Apparent increase due to fertilizers: No. of Marketable ears*	*Apparent increase due to fertilizers: Total Wt. of all ears in Kg.*
None..	1,9 & 19	137	35.5		
N.....	2 & 5	144	33.3	7	–2.2
P.....	3 & 6	154	36.2	17	.7
K.....	4 & 7	132	32.8	– 5	–2.7
Ca'....	8	133	31.5	– 4	–4.0
NP....	10 & 11	158	39.7	21	4.2
NK...	12 & 13	136	37.9	– 1	2.4
Ca''...	14	159	42.8	22	7.3
PK....	15 & 16	166	38.4	29	2.9
NPK..	17 & 18	162	40.1	25	4.6

Nitrogen had very little effect. It seemed to accomplish less than it did in the first culture.

Potassium accomplished about the same as in the first culture. Estimating its effects according to either marketable ears or total weight of all the ears, we have for its yield, when applied alone, less than the average of the check plots. In combination with nitrogen it made almost the same number of marketable ears as the check plots, with slightly greater total weight. As was shown above, its combinations with P and with NP are remarkable. These effects, however, are probably due, not to the potash, but principally to the phosphorus.

Lime gave effects quite different from those of the first culture. In the second culture we have for the better yielder, the plot 14 which received 24 Kg. (2000 Kg. per Ha.) and the smaller yielder, whose yield is even smaller than the average of the check plots, the plot which received 12 Kg. (1000 Kg. per Ha.), plot 8.

Valuing the yields the same as was done in the first culture, we have the following table:

THE VALUE OF THE YIELD, COST OF PRODUCTION, AND PROFIT OR LOSS PER PLOT

PLOT	VALUES OF EARS: *Marketable*	*Unmarketable*	*Culls*	*Total Value*	*Cost of Production*	*Profit or loss*
	₱	₱	₱	₱	₱	₱
Check*.	1.37	.16	.03	1.56	.72	+ .84
2.....	1.49	.13	.04	1.66	2.19	— .53
3.....	1.61	.14	.03	1.78	.92	+ .86
4.....	1.48	.16	.02	1.66	1.04	+ .62
5.....	1.39	.14	.03	1.56	2.05	— .49
6.....	1.46	.18	.03	1.67	.90	+ .77
7.....	1.16	.16	.04	1.36	1.03	+ .33
8.....	1.33	.15	.03	1.51	1.00	+ .51
10.....	1.52	.16	.04	1.72	2.14	— .42
11.....	1.64	.17	.05	1.86	2.01	— .15
12.....	1.57	.19	.03	1.79	2.23	— .44
13.....	1.14	.16	.04	1.34	2.12	— .78
14.....	1.59	.17	.04	1.80	1.28	+ .52
15.....	1.55	.14	.03	1.72	1.85	— .13
16.....	1.77	.14	.05	1.96	1.91	+ .05
17.....	1.60	.17	.03	1.80	2.69	— .89
18.....	1.63	.16	.02	1.81	2.72	— .91

As this table shows, plot 3 (double superphosphate) was the most profitable, the average of the check plots second, plots 6 (single superphosphate) third, plot 7 (sulphate of potash) fourth, plot 8 (Ca') sixth, plot 7 (muriate of potash) seventh, and plot 16 (double superphosphate and sulphate of potash) eigth. The other plots did not pay their cost of production. It will be noticed that the check plots have even slightly larger profit than any of the other plots that paid more than the cost of production, except only plot 3. If, however, the profits of plots 3 and 6 (the phosphoric acid plots) were averaged, it would be found to be less than that of the checks.

It might appear from the above, that the application of commercial fertil-

* Average of plots 1, 9 and 19.

izers to this soil is not profitable. But in the calculation of the value of the effects of the fertilizers, their residual effects must be taken into consideration. Since the measurement of the residual effects of these fertilizers for this soil is not within the scope of this paper, we are not able to definitely state how much of each kind of fertilizer remains in the soil at the close of the experiment. The fertilizer combinations that gave profits about the same as those of the check plots, will in the end give better net profits. Hence, plots 3 , 6 and 8 (respectively phosphoric acid, phosphoric acid and lime plots) can be considered profitable plots; and phosphoric acid and lime can be regarded and recommended as profitable fertilizers for this soil.

Comparison of Commercial and Natural Fertilizers

By comparing the results of the present experiment with the results of Mr. Camus' (1) experiment, in which ashes, manure and leguminous crops were used instead of commercial fertilizers, we can determine which of the two classes of fertilizers it is better to recommend for use, either for the College soils or in other localities in the Philippines having the same or similar soil. It is especially important to determine which of the two kinds of fertilizers can be recommended for use by the small farmer. As was shown above, if the profits derived from the use of the commercial fertilizers were based solely on the first crop of corn, there would be but little gain. This fact may lead one to think that commercial fertilizers cannot be used with profit and that for this given soil, green manures (legumes), animal manures and ashes should be recommended instead. But if the possible residual effects of the commercial fertilizers are included in the calculation, the final net profits in most cases would be found to be greater than obtained in Mr. Camus' fertilizer experiments. Ashes, green and animal manures may leave some considerable residual effects, but those of the commercial fertilizers are likely to be much greater, as they are richer in plant food elements.

It cannot then be positively stated which of these forms of fertilizers it would be better to recommend. It is clear that phosphoric acid in the form of either single or double superphosphate and lime can be used with considerable profit, if used judiciously. It is also very profitable to apply readily accessible farm manures, and to plow under legumes, for they not only improve the chemical composition of the soil, but its physical and bacteriological conditions as well.

As indicated by these experiments, the safest procedure is to use phosphoric acid, of commercial fertilizers, and lime; but if potash is to be used, it is preferably in the form of ashes, and nitrogen is best applied in the form of either manure or legumes.

The following tables show the profits in pesos per hectare obtained by Mr. Camus and from the experiment of the writer:

MR. CAMUS' RESULTS

Rank	*Name of fertilizers*	*Amount*	*Profit*
			₱
1	Ashes and Manure (ave. of 1st and 2nd)	10 c.m. each	90.84
2	Ashes (ave. of 1st and 2nd cultures)	20 c.m.	51.06
3	Manure and Lime	6 c.m. each	48.16
4	Manure (ave.)	20 c.m.	43.08
5	*Patani (*Phaseolus lunatus*)	Light	39.84
6	**Centrosema*	Heavy	36.97
7	*Soy bean	Light	31.74
8	**Cajanus*	Light	31.66
9	Lime	6 c.m.	24.42
10	Check	—	13.25
11	**Centrosema*	Very light	8.23

* Green manures.

THE RESULT OF THE PRESENT EXPERIMENT

(*Average of the first and second culture*)

Plot No.	Name of fertilizers	Profit per Ha. Excluding residual effects.
Check	None	58.19
2	Nitrate of soda	50.71
3	Double superphosphate	56.85
4	Sulphate of potash	38.41
5	Sulphate of ammonia	45.78
6	Single superphosphate	53.46
7	Muriate of potash	18.88
8	Lime (at the rate of 1000 Kilograms per Hectare)	38.28
10	Sulphate of ammonia and double superphosphate	43.23
11	Nitrate of soda and single superphosphate	21.11
12	Sulphate of ammonia and sulphate of potash	62.18
13	Nitrate of soda and muriate of potash	77.79
14	Lime (2000 Kilograms per Hectare)	39.71
15	Single superphosphate and muriate of potash	41.65
16	Double superphosphate and sulphate of potash	55.25
17	Nitrate of soda and double superphosphate and sulphate of potash	90.71
18	Sulphate of ammonia, single superphosphate and sulphate of potash	90.37

These results seem to warrant the broader application of the recommendations of the great Illinois corn expert C. G. Hopkins ([XI]), "that in profitable systems of general farming nitrogen should be secured from the air, potassium should be liberated from the inexhaustible supply naturally contained in all normal corn-belt soils, and that phosphorus should be purchased and applied liberally in low-priced fine-ground natural rock phosphate, ground lime-stone (likewise a low-priced natural fertilizer) also being used where needed."

Our results seem to be in line, in a general way, with M. Barrowcliff's report on the results of the mechanical and chemical analyses of different kinds of Malayan soils with reference to plant-food content and fertilizer requirements, in which he shows "that the soils are as a rule rich in humus and nitrogen and almost totally lacking in lime. They have a high clay content and are consequently abundantly supplied with potash, which, however, is not very available. The phosphorus content is variable. Correlating the yields with the chemical analysis, it appears that available phosphate is, as a rule, the controling element of fertility, especially in the paddy soil" ([XII]).

Conclusions

1. To use reasonable amounts of double or single superphosphates is profitable for this soil.

2. Corn does not apparently show any sign of prefering one form of fertilizer to another as a means of supplying the same element of plant food.

3. Applying large amounts of commercial nitrogenous fertilizers does not pay here.

4. Five hundred to one thousand, five hundred kilograms per hectare of lime, broadcasted, is a safe application for our heavy soil, and is profitable.

5. NPK combinations greatly hasten the increase of height; N alone invigorates the plant, causing development of large deep-green leaves and heavy stalks; and K seems to affect the development of all the parts of the plant.

Acknowledgment

The writer desires to express his thanks to Professor C. F. Baker for helpful suggestions and assistance in the preparation of this thesis.

References

(I) *Philippine Agriculturist and Forester*, Vol. I, No. 10; Vol. III, No. 3.
(II) *Hopkins' Soil Fertility and Permanent Agriculture*, p. 568.
(III) *Frap's Principles of Agricultural Chemistry*, p. 88.
(IV) *Maryland Agricultural Experiment Station, Bulletin* No. 89.
(V) *Kentucky Agricultural Experiment Station, Bulletin* Nos. 17, 33 and 45.

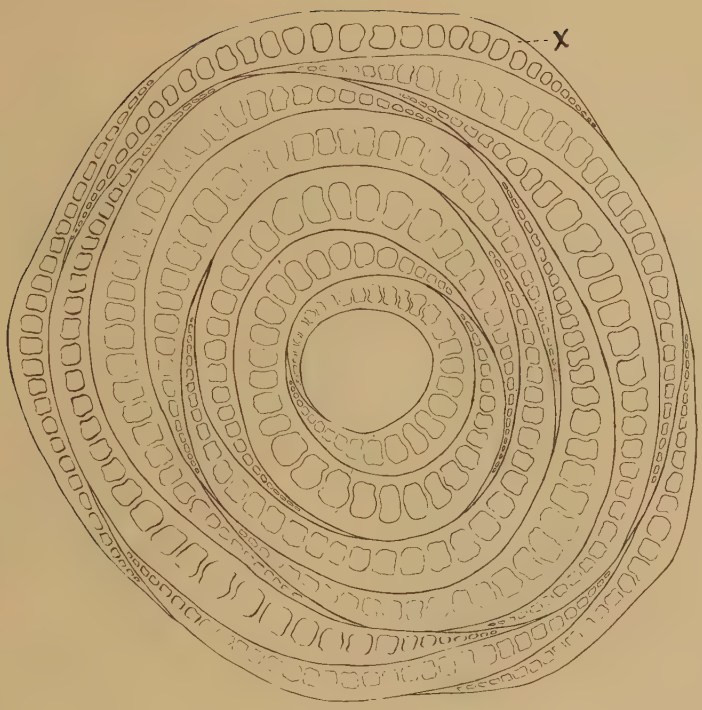
(VI) *Massachusetts Agricultural Experiment Station, Bulletin* No. 14, May, 1891; *Bulletin* No. 9, May, 1890.
(VII) *University of Georgia, Bulletin*, January, 1911; Special No. 150. *Georgia Experiment Station, Bulletin* No. 97, November, 1911.
(VIII) *Texas Agricultural Experiment Station, Bulletin* No. 138, April, 1911.
(IX) *Experiment Station Record, 30*, 220; *34*, 427.
(X) *New South Wales Farmers' Bulletin* No. 78, June, 1914.
(XI) *Experiment Station Record, 29*, p. 623.
(XII) *Experiment Station Record, 29*, p. 727.

QUOTATION FROM REPORT OF MEETING OF THE ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS

While the chief purpose of this plan is usually educational, the immediate advantages to the station work are not to be overlooked. In an increasing number of institutions graduate students are being utilized in conducting the station investigations, and in some instances this is looked upon as an economical means of securing assistance. Some have gone so far as to divide their main theme or project into various parts which can be worked out independently and assigned to advanced students to be conducted under the general direction of the leader of the project. The real advantage of this to the station depends largely on the nature of the subject and on the men assigned to it. The right kind of graduate assistants may be a real help, as has often been found to be the case, but instances have also occurred in which men well recommended by other institutions have proved disappointing as graduate assistants.

"Evidently the station work must not be contingent upon this type of service, or subordinated in any sense to the purpose of teaching. It is based on the plan of the university in making provision for graduate work, and it is well recognized as largely a phase of the teaching activity. As a teaching function the responsibility for it should rest usually with the college or university, and for that reason doubtless the college has in specific instances provided the fellowships. Unless there is some direct advantage or aid to the station, it will rarely be able to do more than a quite limited amount in this direction. But the community of interest among the stations in promoting more thorough preparation of men for research work makes efforts of this kind worth encouraging.

"Discussion of the best means of securing recognition and credit for station work through the extension staff brought out the fact that the attitude of the extension worker is a large factor in this matter, and that his closeness to the public affords a means of giving wide publicity to the station work and emphasizing its importance. The close contact which the stations formerly had with the public, through meetings, correspondence, personal visits, etc., will be diminished as the extension work is segregated and grows in extent. Obviously, the extension man can ill afford to claim to be the original source of the information he gives out, and the importance to his work of maintaining the support for station activity should lead him and those in general charge of the extension enterprise to give full prominence and credit to the station.



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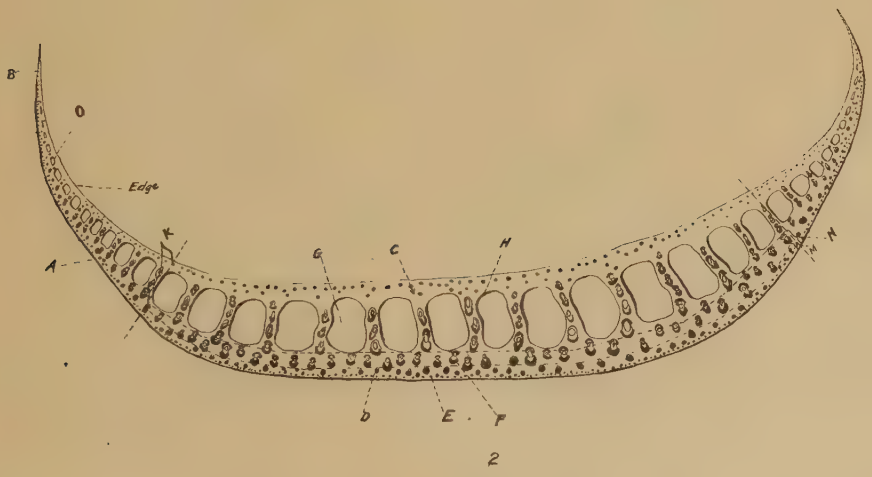

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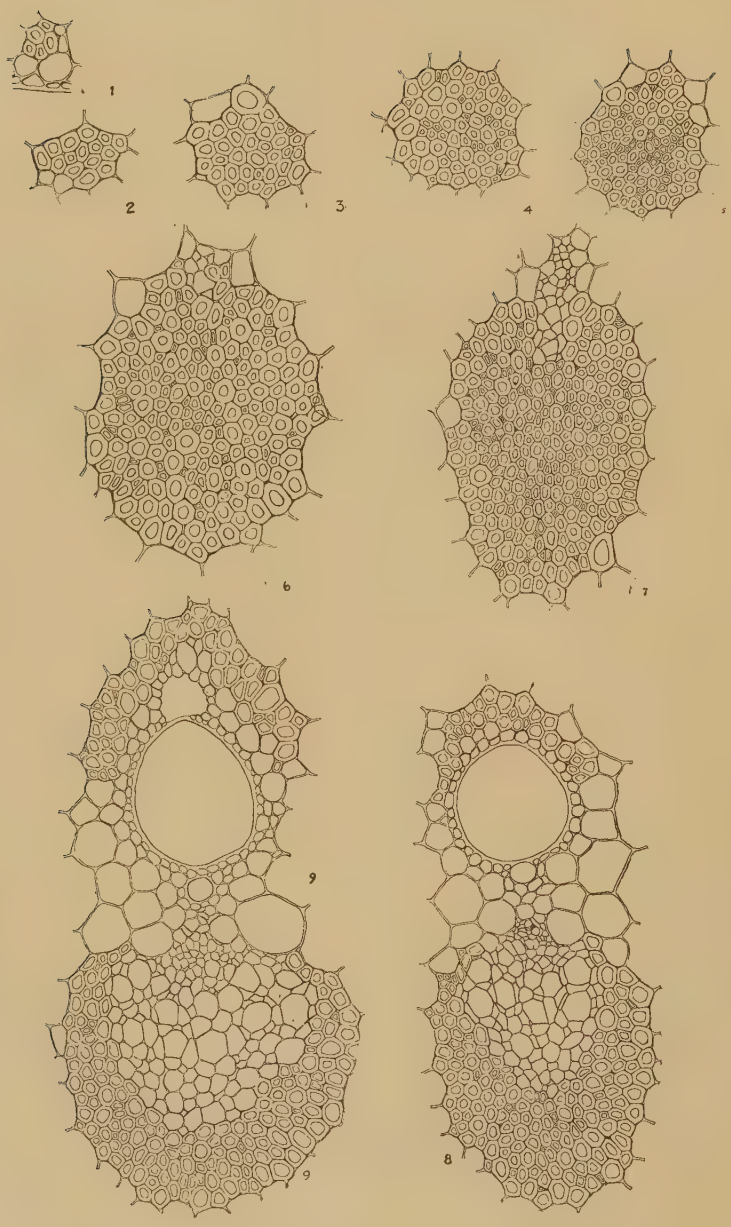
PLATE I



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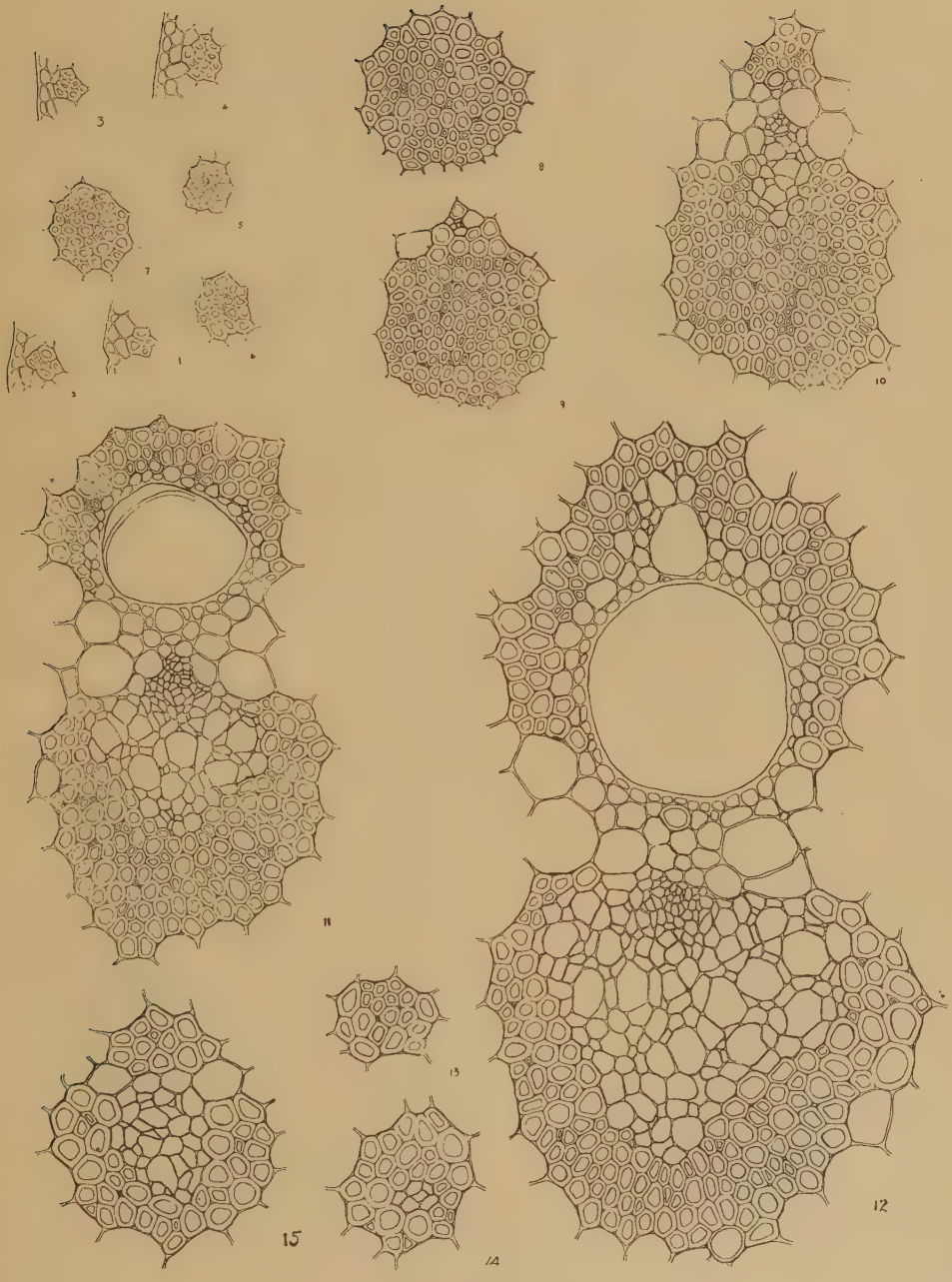

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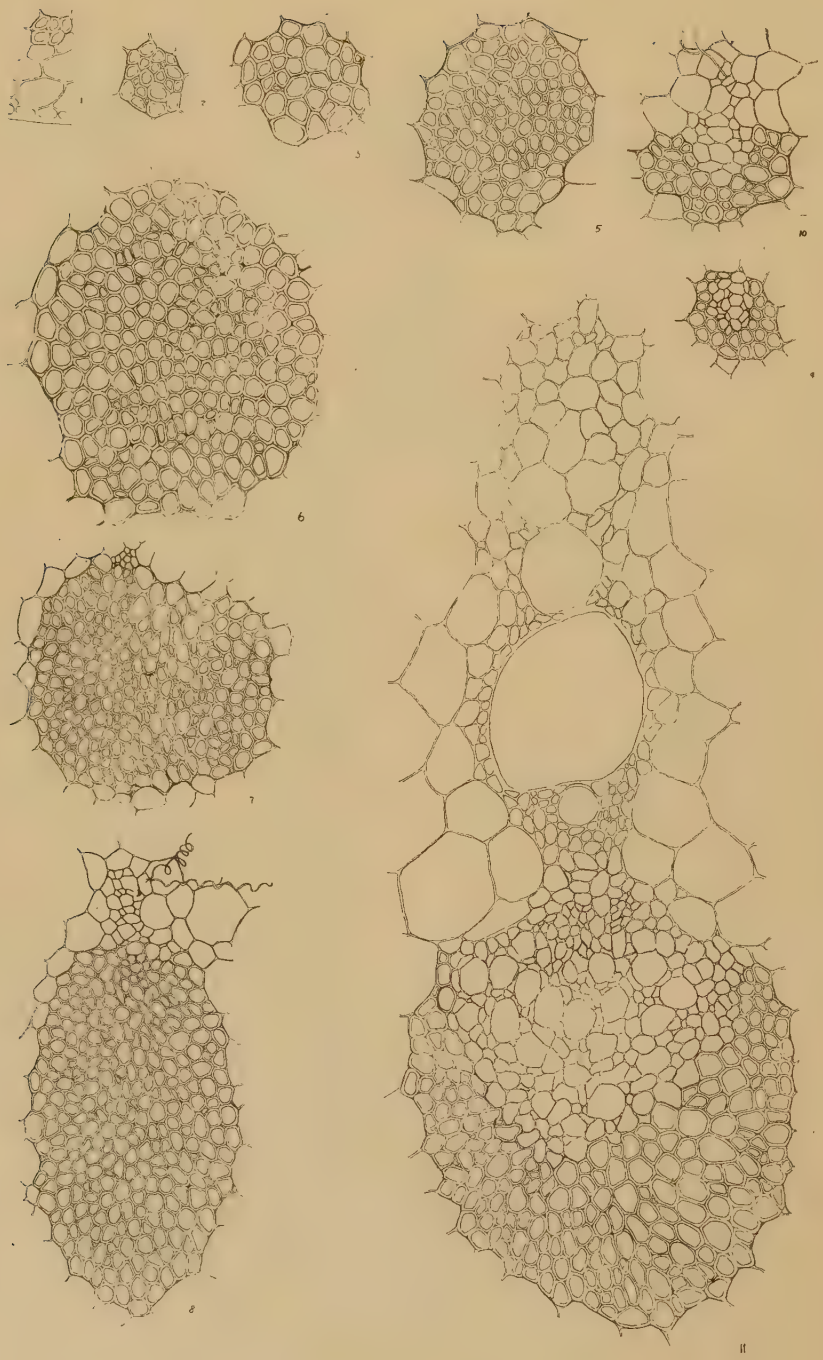

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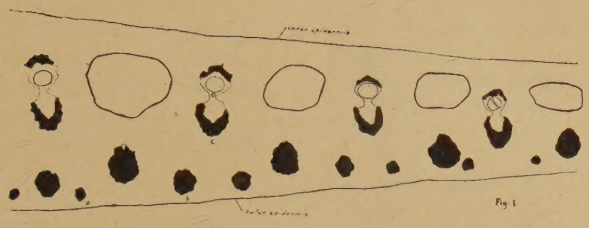
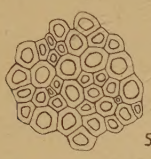


Fig. 1

Fig. 2



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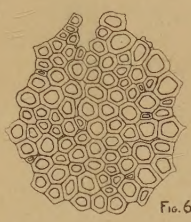


Fig. 6

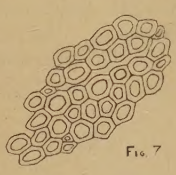


Fig. 7

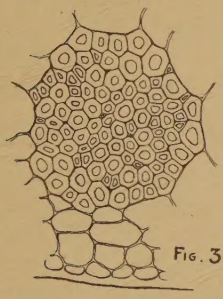
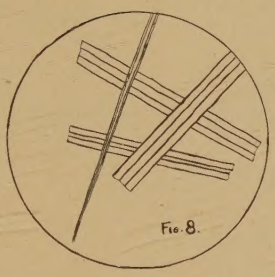


Fig. 3



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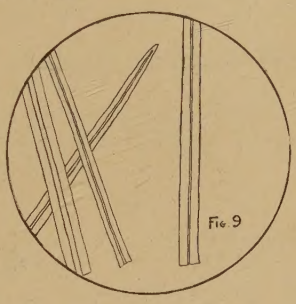

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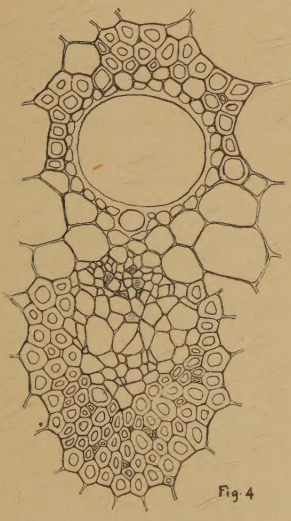

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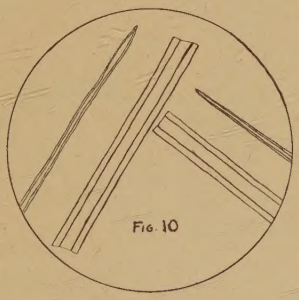

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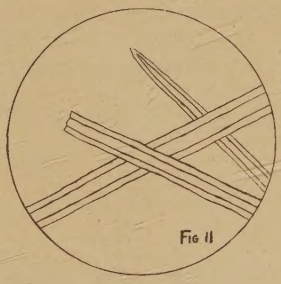

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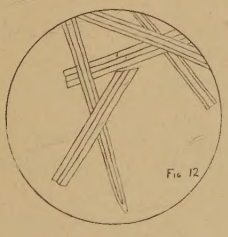

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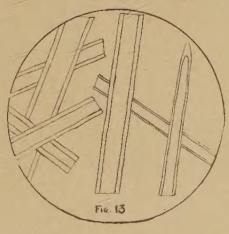

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The EDITORS